Alan CTR, WTR-2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 9

75 Hawthorne Street
San Francisco, CA 94105-3901

APR 2 8 1997

Mr. Norman Wei
Corporate Environmental Manager
StarKist Foods, Inc.
1054 Ways Street
Terminal Island, CA 90731

Mr. James L. Cox
Director of Engineering and
Environmental Affairs
Van Camp Seafood Company, Inc.
4510 Executive Drive, Suite 300
San Diego, CA 92121-3029

Subject: Administrative Extension of the Marine Protection, Research and Sanctuaries Act (MPRSA) Section 102 Special Ocean Disposal Permits, OD-93-01 and OD-93-02

Dear Mr. Wei and Mr. Cox:

Pursuant to the Administrative Procedures Act (5 U.S.C. Section 558), we have decided to administratively extend the ocean disposal permits of StarKist Samoa (OD-93-01) and VCS Samoa Packing (OD-93-02) until August 31, 1997. We are continuing to evaluate the information submitted by StarKist Samoa and VCS Samoa Packing as required by the present permits and will reissue these permits by this date. Draft permits will be submitted for your review prior to this time.

Should you have any questions on this administrative extension or your permit requirements, please call Pat Young, American Samoa Program Manager at (415) 744-1594.

Sincerely,

Mike Schulz
for Alexis Strauss, Director
Water Management Division

cc: Togipa Tausaga, ASEPA, American Samoa
U.S. Coast Guard Liaison Officer, American Samoa
Barry Mills, StarKist Samoa, American Samoa
William Perez, VCS Samoa Packing Company
Michael Burns, Blue North Fisheries, Seattle, WA
Steve Costa, GDC
Karin, Noack, CH2M Hill

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

AUG 2 0 1996

James Cox, Director
Engineering and Environmental Affairs
Van Camp Seafood Company, Inc.
4510 Executive Drive, Suite 300
San Diego, CA 92121-3029

Subject: Administrative Extension of MPRSA Section 102 Ocean Dumping Permit, #OD 93-02

Dear Mr. Cox:

EPA Region IX is evaluating the information submitted by StarKist Samoa and VCS Samoa Packing as required by the Marine Protection, Research and Sanctuaries Act (MPRSA) Section 102 special ocean dumping permit. Due to the late submittal by CH2MHILL of the report titled, "Joint Cannery Ocean Dumping Studies in American Samoa", the overall complexity of these evaluations, and the approaching expiration date of MPRSA Section 102 special permit #OD 93-02, EPA Region IX has determined that we will administratively extend MPRSA Section 102 special permit #OD 93-02. The administrative extension is made according to procedures defined in the Administrative Procedures Act (5 U.S.C. § 558). We anticipate that a decision on the new permit will be made within 90 days after expiration (on August 31, 1996) of the existing special permit..

EPA Region IX will inform you as soon as possible about our decision for the final permit, after which we will submit a draft permit for your review. If you have any questions on the administrative extension or your MPRSA Section 102 permit (OD 93-02) requirements, please call me at (415) 744-2125, or you may call Patricia Young at (415) 744-1594.

Sincerely,

A Strauss

Alexis Strauss, Director (acting)
Water Management Division

cc: Tony Tausaga, ASEPA, Pago Pago, American Samoa
U.S. Coast Guard Liaison Officer, Pago Pago, American Samoa
William D. Perez, VCS Samoa Packing, Pago Pago, American Samoa
Michael Burns, Blue North Fisheries, Seattle, WA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

James Cox, Director
Engineering and Environmental Affairs
Van Camp Seafood Company, Inc.
4510 Executive Drive, Suite 300
San Diego, CA 92121-3029

Subject: Administrative Extension of MPRSA Section 102 Ocean Dumping Permit, #OD 93-02

Dear Mr. Cox:

EPA Region IX is evaluating the information submitted by StarKist Samoa and VCS Samoa Packing as required by the Marine Protection, Research and Sanctuaries Act (MPRSA) Section 102 special ocean dumping permit. Due to the late submittal by CH2MHILL of the report titled, "Joint Cannery Ocean Dumping Studies in American Samoa", the overall complexity of these evaluations, and the approaching expiration date of MPRSA Section 102 special permit #OD 93-02, EPA Region IX has determined that we will administratively extend MPRSA Section 102 special permit #OD 93-02. The administrative extension is made according to procedures defined in the Administrative Procedures Act (5 U.S.C. § 558). We anticipate that a decision on the new permit will be made within 90 days after expiration (on August 31, 1996) of the existing special permit..

EPA Region IX will inform you as soon as possible about our decision for the final permit, after which we will submit a draft permit for your review. If you have any questions on the administrative extension or your MPRSA Section 102 permit (OD 93-02) requirements, please call me at (415) 744-2125, or you may call Patricia Young at (415) 744-1594.

Sincerely,

Alexis Strauss, Director
Water Management Division

cc: Tony Tausaga, ASEPA, Pago Pago, American Samoa
U.S. Coast Guard Liaison Officer, Pago Pago, American Samoa
William D. Perez, VCS Samoa Packing, Pago Pago, American Samoa
Michael Burns, Blue North Fisheries, Seattle, WA

CONCURRENCES

SYMBOL	W-3-3	C-4	E-4	W-3				
SURNAME		P. Young	M. Lacton					
DATE	8/19-96	8/20/96	8/20/96	8-20-96				

EPA Form 1320-1 (12-70) OFFICIAL FILE COPY

*U.S. GPO : 1986-159-319

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A Division of Star-Kist Foods, Inc.
P.O. Box 368
Pago Pago, Tutuila Island
American Samoa 96799
Telephone: 684 644-4231
Facsimile: 684 644-2440

Alan - can you email me thoughts/comments w/re: to ↕ sections:
Carl

February 16, 2001

Mr. Carl Goldstein
United States Environmental Protection Agency
Region 9
75 Hawthorne Street
San Francisco, CA 94105

RE: <u>Meeting at StarKist Samoa On January 31, 2001</u>

Dear Carl:

Thank you for taking the time to meet with us during your recent visit to Samoa which included your annual visit to the StarKist facility. We felt that the meeting was very productive and would like to confirm our understanding of several items that were discussed.

The first issue is the renewal of our Ocean Dumping Permit. We were surprised to learn that OD98-01, under which we thought we had been operating, never went into effect. Instead, we now understand, the previous permit OD93-01 remains in effect. We also understand that there is no need for us to make application for a new permit as the process is currently underway in your office. We will continue in the meantime to operate under the OD-93-01 Permit, to which we changed immediately following your visit.

In conjunction with the pending Ocean Dumping Permit application, we asked you to research whether a second permitted dump site could be established, or alternatively a site not subject to permitting requirements. This would be used on rare occasions when wind and/or sea conditions could cause the permitted waste stream to migrate towards the Tutuila beaches. Again, we ask that you look into this possibility so that when the new permit is finally drafted, we may include a provision to that effect. We propose that this should be further out into the ocean than the current permitted dump site.

In light of our discussion on the incidents in December when the canneries were dispatched to clean Alega beach, we conducted further research into the definition of Floatables. It is our conclusion that the permitted waste stream, if floating temporarily at the permitted waste site, is not included in the definition of Floatables under the various relevant Acts. Floatables appear to be items like "plastic, aluminum cans, wood products, bottles and paper products." We are anxious to receive confirmation from you that this is a correct interpretation so we can further instruct the Tasman Sea as to their log entries and notice policies.

Finally, we confirm our interest in reviewing the Water Shed Management Program Proposal of which you spoke. As good corporate citizens, we have an interest in maintaining the environmental quality of the harbor and the area in which we have operations. This program sounds very interesting and we are anxious to hear more about it.

It was a pleasure meeting with you and the rest of your team. We look forward to resolving all of the issues that we discussed during that meeting and hope for productive solutions.

Yours Sincerely,

STARKIST SAMOA, INC.

Phil Thirkell
General Manager

Cc: Janet Rich
John Brown
Joe Carney
Barry Mills

gdc

COASTAL ENVIRONMENTAL ANALYSTS

12 February 1998

Terry Oda
U.S. Environmental Protection - Region 9
75 Hawthorne Street
San Francisco, CA 94105

Dear Terry,

Re: Proposed Ocean Dumping Permit for COS Samoa Packing
Request for Higher Limits for Total Solids and Total Volatile Solids

I am sending this correspondence on behalf of COS Samoa Packing. I have been involved with a number of the studies required under the existing ocean dumping permits for the tuna canneries in American Samoa as a consultant to Samoa Packing. I am familiar with the activities and permit requirements involved and have reviewed the proposed draft permits.

When the application for renewal of the existing permit was submitted, all available monitoring data were included. The proposed new permit limits were based on these data. Since the application was submitted additional monitoring data have been collected and submitted to EPA.

Based on the data submitted, the draft permit reduces the limit for total solids from 54,590 mg/l to 43,170 mg/l and reduces the limit for total volatile solids from 58,760 mg/l to 38,320 mg/l. These reductions were based on the data available throughout the period of the existing permit to the time the permit renewal application was submitted. However, more recent data, generally the last half of 1997, show higher concentrations that are more consistent with the previous limits. A summary of all available data (September 1993 through November 1997) was sent to Carl Goldstein, American Samoa Program Manager for EPA in a letter from Jim Cox on January 6, 1998 requesting a review and increase of the proposed limits.

The nature of the high strength waste, composed of a number of individual waste streams from the cannery, results in substantial and unavoidable variability from day-to-day. A summary of the statistics describing the data set is shown in the table below. In the table below I have also shown the results of the "reasonable potential calculations" based on EPA's method in the TSD for Water Quality-based Toxics Control. However, the extreme variability found in the data probably argues against application of this methodology - the results are included simply for illustration. I suggest consideration of applying a limit based on your examination of the data set and using some measure such as the mean plus two standard deviations.

COS Samoa Packing would appreciate your review of the data and requests that the proposed draft limits for these two constituents be revised upward to avoid the potential of permit violations. The ocean dumping studies performed jointly for Samoa Packing and StarKist Samoa clearly indicate that such an adjustment would not lead to an increased potential for environmental degradation in the waters surrounding the designated dumping zone. As an major participant in conducting the special studies (bioassay and dilution modeling) for the existing permit, I am familiar with the site and the

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study results. In my judgment, even within the permitted dumping zone, any changes in water quality resulting from higher limits would be negligible and probably unmeasurable.

Thank you for your time and consideration of this matter. Please call me directly, or contact Jim Cox at Chicken of the Sea International, if you have any questions or require additional information.

Sincerely,

Steven L. Costa, Ph.D.

cc: Jim Cox, Chicken of the Sea International
Carl Goldstein, EPA Region 9, American Samoa Program Manager
David Wilson, CH2M HILL/SEA
Karin Noack, CH2M HILL/SFO

Total Solids and Total Volatile Solids Concentrations (mg/l)
COS Samoa Packing
September 1993 - November 1997

Statistic	Total Solids	Total Volatile Solids
Minimum	5,390	897
Maximum	86,900	72,800
Mean	27,205	17,847
Standard Deviation (SD)	19,616	16,821
CV	0.72	0.96
Mean + 2(SD)	66,437	51,128
Reasonable Potential at 99% CL, 95% Probability[1]	95,600	80,100
Reasonable Potential at 99% CL, 99% Probability[1]	139,000	131,000

[1] Calculations based on method given in the "Technical Support Document for Water Quality-based Toxics Control", EPA, 1991.

Mailing list
12/15/97

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FACT SHEET

SPECIAL OCEAN DUMPING PERMITS

STARKIST SAMOA (OD 98-01) AND
VCS SAMOA PACKING COMPANY (OD 98-02)
LOCATED IN PAGO PAGO, AMERICAN SAMOA

I. SUMMARY

The U.S. Environmental Protection Agency (EPA) Region IX has received complete applications from StarKist Samoa, Incorporated and VCS Samoa Packing Company, Incorporated for continued ocean disposal of fish processing wastes off Pago Pago, American Samoa. Disposal of fish processing wastes was permitted under two previous Marine Protection Research and Sanctuaries Act (MPRSA) 102 Special Permits, OD 93-01 (StarKist Samoa) and OD 93-02 (VCS Samoa Packing). These permits began on September 1, 1993 and were effective until August 31, 1996. Administrative extensions have allowed use of the site since that date. Disposal operations occurred at a designated site (55 FR 3948, February 6, 1990) located 5.45 nautical miles from land (14° 24.00' South latitude by 170° 38.20' West longitude) with a radius of 1.5 nautical miles in about 1,500 fathoms of water. The Regional Administrator has tentatively decided to issue special ocean dumping permits (OD 98-01 and OD 98-02, respectively) to the applicants for ocean disposal of fish processing wastes over a three-year period. This decision has been made according to EPA's authority established in Title I of the Marine Protection, Research and Sanctuaries Act of1972 (MPRSA) (33 U.S.C. section 1401 et seq.). Section 104B(k)(3)(B) of MPRSA contains an exclusion from the ban on disposal of industrial waste for tuna canneries in American Samoa. The conditions and monitoring activities defined in OD 98-01 and OD 98-02 are similar to those in previous special and research ocean dumping permits. However, several changes and/or clarifications have been made to: 1) permitted waste concentrations, 2) combined waste stream monitoring from the onshore storage tank, 3) reporting requirements, and 4) disposal vessel operations. The changes are based on evaluation of waste stream data, confirmation of past toxicity tests and plume modeling and new navigation requirements for the disposal vessel. EPA Region IX has tentatively decided to proceed with issuance of these special permits. Comments on our proposed action will be requested from the permit applicants, the American Samoa Government, Federal agencies, and the public as required under EPA's Ocean Dumping Regulations at 40 C.F.R Parts 220 through 228. Draft special permits and supporting documents are available for public review at the U.S. EPA's Regional Office in the Library on the 13th Floor at 75 Hawthorne Street, San Francisco, California; the U.S. EPA's Pacific Island Contact Office, 300 Ala Moana Boulevard, Honolulu, Hawaii; and the American Samoa Environmental Protection Agency, Executive Office Building, Office of the Governor, Pago Pago, American Samoa. These documents define the principal facts and significant legal, administrative and policy questions considered in the development of the special permits.

II. TENTATIVE DECISION

On February 23, 1996 and February 26, 1996, respectively, StarKist Samoa and VCS Samoa Packing Company applied for ocean dumping permits to dispose of their fish cannery wastes at a designated ocean disposal site near Pago Pago, American Samoa. The designated site, used for the past 3 years by both canneries, is located 5.45 nautical miles from land (14° 24.00' South latitude by 170° 38.20' West longitude) with a radius of 1.5 nautical miles in 1,502 fathoms of water [40 C.F.R. 228.12(b)(74)]. EPA Region IX is planning to grant their applications by issuing a special ocean dumping permit to each cannery which will last for three years. Current information indicates that disposal of fish processing wastes at the designated site complies with EPA's Ocean Dumping Regulations at 40 C.F.R. Parts 227 and 228. Information obtained during the term of the special permits will be used to evaluate whether the disposal of fish processing wastes continues to comply with criteria defined in EPA's Ocean Dumping Regulations. The permittees must conduct a site monitoring program, including field and laboratory analyses. Results of the monitoring program will be used to document the extent of effects at the ocean disposal site and whether the dumping continues to comply with EPA's Ocean Dumping Regulations. The proposed dumping during the term of the special permits is expected to have minimal impacts on human health and/or the marine environment, as demonstrated by the monitoring results of the previous special and research ocean dumping permits. The primary environmental impact of the proposed discharges would be short-term increases in turbidity, inorganic nutrients, oil and grease, and ammonia during the dumping events. Past monitoring studies on the disposal of fish processing wastes off American Samoa show that water quality parameters return to ambient conditions at the boundary of the disposal site following the four-hour period of initial mixing (40 C.F.R. 227.29). To be certain that American Samoa Water Quality Standards would not be violated by the disposal of fish processing wastes, the center of the disposal site was designated 5.45 nautical miles offshore, and restrictive navigation requirements, disposal rates and limitations on the waste material constituents are included in the special ocean dumping permits.

III. TERMS OF THE PERMIT

Special ocean dumping permits OD 98-01 and OD 98-02 are similar to OD 93-01 and OD 93-02, except those changes outlined above. The permittees have been disposing of fish cannery wastes, monitoring the waste streams and the disposal site according to the specifications of the past special and research permits.

A. Volumes of Waste Material Proposed for Ocean Disposal

Table 1. Volumes of Fish Processing Waste Authorize for Daily Disposal (see Special Condition 2.3 in both permits).

Fish Processing Waste	**StarKist Samoa (gallons/day)**	**VCS Samoa Packing (gallons/day)**	**Total Volume (gallons/day)**
Daily Maximum - Combined Waste Stream from Onshore Storage Tank	200,000	200,000	400,000

B. Waste Material Limitations in the Proposed Permits (see Special Condition 2.4 in both permits).

Table 2. Combined Fish Processing Waste Limits for the StarKist Samoa's Permit #OD 98-01 and VCS Samoa Packing Company's Permit #OD 98-02.

Storage Tank Physical or Chemical Parameter (units)[a]	**Starkist Samoa**	**VCS Samoa Packing Company**
Total Solids (mg/L)	101,800	43,170
Total Volatile Solids (mg/L)	84,100	38,230
5-Day BOD (mg/L)	129,390	53,350
Oil and Grease (mg/L)	62,940	119,750
Total Phosphorus (mg/L)	1,750	2,880
Total Nitrogen (mg/L)	10,980	11,330
Ammonia (mg/L)	11,810	4,580
pH (pH units)	6.2 to 7.1	5.8 to 7.4
Density (g/mL)	0.97 to 1.03	0.98 to 1.02

a = All calculated values were rounded to the nearest 10, except the density and pH ranges.

IV. CALCULATION OF PERMIT LIMITS

Data from the previous special ocean dumping permit issued to each cannery were used to calculate all permit limits. The data for each cannery were evaluated separately. The following calculations were made for each set of data using the LOTUS spreadsheet program, version 4: maximum and minimum levels; mean, standard deviation and the number of data points. Any data values greater than or less than the mean plus or minus 2 standard deviations, were considered to be outliers. Outlier data points were not used in the permit limit calculations. All procedures for calculating permit limits are discussed in Sections 3.1.1 and 3.1.2 (pages 3-1 to 3-9) of EPA's Guidance Document for Ocean Dumping Permit (January 30, 1988).

V. FACTORS CONSIDERED IN REACHING THE PERMIT DECISIONS

Overview of Disposal Operations

The two fish canneries in American Samoa, StarKist Samoa and VCS Samoa Packing Company, propose to dispose of fish processing wastes at an ocean dump site centered approximately 5.45 nautical miles south of Tutuila Island in 1,502 fathoms of water. The center coordinates of the site are: 14° 24.00' South latitude by 170° 38.20' West longitude. The fish processing wastes will be transported to the upcurrent quadrant of the site and discharged at a rate less than or equal to 1,400 gallons per minute, depending on the season, at a maximum speed of 10 knots (see Special Condition 4.4.1). The disposal vessel will discharge the fish processing wastes within a target area defined by an oval-shaped track with the center axis of the oval perpendicular to the current direction. This target area for disposal is located within the boundary of the designated ocean disposal site. On each trip, the master of the disposal vessel will document current direction at the center of the disposal site. He will then proceed to a point 1.1 nautical miles upcurrent of the prevailing surface current to discharge the waste. The fish processing wastes may be discharged only after this procedure has been conducted. This will ensure that the waste plume has an adequate area for mixing within the disposal site boundary. Receiving waters at the disposal site are outside the American Samoa territorial sea. Though the ocean disposal site is outside these waters, the MPRSA 102 special permits are designed to comply with oceanic water quality standards defined in § 24.0207(g)(1-7) of the American Samoa Water Quality Standards (see Table 1 under General Condition 1.5). This will ensure that oceanic waters inside American Samoa's territorial sea are not affected by the ocean disposal operations. Within four hours after dumping has ceased, concentrations of the fish processing wastes must reach ambient levels at the disposal site boundary. After four hours, these concentrations must not exceed ambient levels at any point in the marine environment (40 C.F.R. section 227.29). Disposal site monitoring requirements are contained in the special permits. EPA Region IX will evaluate potential impacts to water quality based on the site monitoring reports.

Changes from the Previous MPRSA 102 Special Permits

The ocean disposal vessel FV TASMAN SEA will be authorized for the 1998 special permits (see page 1 of each permit). This disposal vessel is owned by Blue North Fisheries, Inc., at 1130 N.W. 45th Street, Seattle, WA 98107-4626. EPA Region IX reviewed waste stream monitoring data (covering a four-year period) submitted by each permittee. The characteristics of the waste streams at the two canneries are entirely different; therefore, separate permits were necessary. Appendix A of this fact sheet contains the tables used to calculate the new permit limits for each permittee's waste stream defined in Section III.B above. In general, the limits for the combined fish waste are increased relative to the previously analyzed individual waste streams, as would be expected.

Results of new confirmatory suspended phase acute toxicity bioassays will be used to calculate new Limiting Permissible Concentration (LPC) values. The new LPC values will be used to rerun the dilution model and confirm compliance with water quality standards at the ocean disposal site. A report will be prepared by each permittee discussing the test procedures and results of the bioassay tests and new model runs. EPA Region IX will review the report to determine whether any changes in the ocean dumping permits are necessary. A computerized navigation system is specified in Special Condition 4.3.4 and 4.5 to simplify plotting of the disposal vessel's track once inside the ocean disposal site and during disposal operations. This system will provide a continuous plot of the disposal vessel's track and a hard copy of each plot will be sent with the 6-month report.

VI. EPA'S AUTHORITY TO ISSUE OCEAN DUMPING PERMITS

EPA's authority to issue special ocean dumping permits is defined under Title I of MPRSA and at 40 C.F.R. 220.4. The authority to issue special permits was delegated to the Regional Administrator on January 11, 1977 (42 FR 2462). The Regional Administrator's authority to issue special permits was redelegated to the EPA Region IX Water Division Director on January 25, 1982 (EPA Region IX Order R1250.5A). Section 102 of MPRSA authorizes EPA to issue permits for ocean dumping. The Agency must determine that the proposed dumping will not unreasonably degrade or endanger human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities. In addition to these requirements, EPA must evaluate each permit application to determine whether the dumping will comply with the criteria at 40 C.F.R. Part 227 and whether the designated site complies with the criteria at 40 C.F.R. Part 228. The American Samoa Fish Processing Waste disposal site was designated, through the publication of a Final Rule, on February 6, 1990 (55 FR 3948) at 40 C.F.R. 228.12(b)(74). The designation process consisted of publication of an environmental impact statement (EIS) according to EPA's voluntary EIS policy. The draft EIS for this project was published on September 16, 1988 (53 FR 38118) and a final EIS was published on March 3, 1989 (54 FR 9083). The final rule designating the ocean disposal site was published on February 6, 1990 (55 FR 3948). EPA Region IX will periodically evaluate the special permits to determine whether the fish canneries disposal operations comply with the special permit conditions. If unacceptable impacts are detected at the site (40 C.F.R. §§ 228.10), or significant permit violations are found, EPA will determine whether use of the site should be restricted (40 C.F.R. §§ 228.10 and 228.11), or whether enforcement actions should be initiated under MPRSA.

VII. ADMINISTRATIVE PROCEDURES AND THE PUBLIC HEARING PROCESS

The processing of an ocean dumping permit consists of the following actions. EPA receives a completed application (40 C.F.R. §§ 221). EPA issues a tentative decision whether to grant or deny the special permit (40 C.F.R. §§ 222.2). A draft permit is the means by which EPA documents the intent to grant an ocean dumping permit. A public notice is issued to announce EPA's intent to issue the permit (40 C.F.R. §§ 222.3). The notice contains the following elements: summary, tentative determination, factors considered in reaching the tentative determination, hearing process, and the location of all information on the draft permit. Public notices describing EPA's intent to issue a permit are published in a daily newspaper in closest proximity to the proposed dump site and in a daily newspaper in the city in which EPA's Regional Office is located. Before a final decision can be made on the special permit, formal consultation must be documented with the following agencies: American Samoa Government, U.S. Army Corps of Engineers, U.S. Coast Guard, National Marine Fisheries Service, U.S. Fish and Wildlife Service and the Shellfish Sanitation Branch of the Food and Drug Administration.

Initiation of a Public Hearing

Within 30 days of the date of the public notice, any person may request a public hearing to consider issuance or denial of the special permit or conditions to be imposed upon this permit. Any request for a hearing must be made in writing; must identify the person requesting the hearing; and must clearly state any objections to issuance or denial of the permit or to the conditions to be imposed upon the permit, and the issues to be considered at the hearing. According to 40 C.F.R. §§ 222.4, the Regional Administrator may schedule a hearing, at his discretion, based on genuine issues presented in the written request. Upon receipt of a written request presenting genuine issues amenable to resolution by a public hearing, the Regional Administrator may determine a time and place for the hearing and publish a notice of the hearing. All interested parties will be invited to express their views on the proposed issuance or denial of the permit at the hearing if one is held. If a request for a public hearing is made within 30 days of the date of this notice and does not meet the above criteria, the Regional Administrator must advise the requesting person of his decision to deny the hearing in writing and proceed to rule on the application. Following adjournment of the public hearing, the Presiding Officer, appointed by the Regional Administrator, prepares written recommendations about the issuance, denial or conditions to be imposed upon the permit after full consideration of the views and arguments expressed at the hearing (40 C.F.R. §§ 222.6 through 222.8). The Presiding Officer's recommendations and the record of the hearing are forwarded to the Regional Administrator within 30 days of the hearing. The Regional Administrator makes a determination whether to issue, deny or impose conditions on the permit within 30 days of receipt of the Presiding Officer's recommendations. He must give written notice of the decision to any person appearing at the public hearing (40 C.F.R. §§ 222.9). A final permit becomes effective 10 days after issuance, if no requests for an adjudicatory hearing are received. Requests for an adjudicatory hearing may be made to the Regional Administrator within 10 days of receipt of the notice to issue or deny the permit (40 C.F.R. §§ 222.10 and §§ 222.11). An appeal of the Regional Administrator's adjudicatory hearing decision may be made in writing to the Administrator of EPA within 10 days following receipt of the Regional Administrator's determination on the need for an adjudicatory hearing (40 C.F.R. §§ 222.12).

VIII. ADDITIONAL INFORMATION

For further information on the special permits, requests for copies of the permits or questions pertaining to MPRSA regulations, please contact either of the following people at EPA Region IX: John Ong, Acting Chief, Monitoring and Assessment Office (WTR-2), U.S. Environmental Protection Agency, 75 Hawthorne Street, San Francisco, California 94105-3901, (415) 744-1156, Carl Goldstein, Office of Pacific Island and Native American Programs (E-4), U.S. Environmental Protection Agency, 75 Hawthorne Street, San Francisco, California 94105-3901, (415) 744-2170.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

OCT 03 1995

James L. Cox
Director of Engineering
and Environmental Affairs
Van Camp Seafood Company, Inc.
4510 Executive Drive, Suite 300
San Diego, CA 92121-3029

Subject: Modification of Waste Stream Monitoring Requirements of Special Ocean Disposal Permit #OD 93-02 for VCS Samoa Packing Company

Dear Mr. Cox:

The U.S. Environmental Protection Agency (EPA) Region IX is modifying the above-referenced special ocean disposal permit, as per Section 3.1.2.4 of this permit, effective October 6, 1995. This modification eliminates existing sampling, monitoring and maximum concentration limitations for the three individual waste streams which are the DAF sludge, precooker water and press water. The modification establishes the onshore fish processing storage tank as the new sampling and monitoring location for the combined individual waste streams and also establishes new maximum concentration limitations for the combined wastes (see Table 3 of the attached amendment). The onshore fish processing storage tank is the holding tank for the three individual waste streams prior to ocean disposal. The new maximum concentration limits for the combined waste stream from the onshore fish processing storage tank have been established based on EPA's review and analysis of data per Special Conditions 3.1.2.2. through 3.1.2.4, OD 93-02.

These modifications to the permit are detailed in the attached pages which replace the corresponding pages in the permit and are hereby incorporated into and made a part of the permit, OD 93-02.

Please be reminded that the permit expires August 31, 1996 and that an application for renewal must be submitted at least 180 days prior to its expiration date. Should you have any questions regarding this revision or re-application, please call Pat Young, American Samoa Program Manager at (415) 744-1594 or Allan Ota, Ocean Disposal Coordinator at (415) 744-1980.

Sincerely,

Amy Zimpfer
Chief, Watershed Protection Branch
Water Management Division

Enclosure

cc: See attached mailing list

2.4. Fish Processing Waste Stream Limits

Table 3. Limits for the Onshore Storage Tank

Physical or Chemical Parameter (units)*	Limits for Onshore Storage Tank
Total Solids (mg/L)	54,590
Total Volatile Solids (mg/L)	58,760
5-Day BOD (mg/L)	87,780
Oil & Grease (mg/L)	48,630
Total Phosphorus (mg/L)	2,820
Total Nitrogen (mg/L)	11,070
Ammonia (mg/L)(mg/L)	5,200
pH (pH units)	5.8 to 7.5
Density (g/mL)	0.97 to 1.03

* All calculated values were rounded to the nearest 10 except density and pH ranges.

2.4.1. Permitted Maximum Concentrations were calculated based on an analysis of data gathered by the permittee through bi-monthly sampling of the onshore waste storage tank, from 9/93 to 9/94, as detailed under Section 3.1.2 of the permit. The calculations followed EPA's recommended procedure for determining permit limits as defined in the EPA document titled: Guidance Document for Ocean Dumping Permit Writers, January 30, 1988. (See attached fact sheet for details.)

EPA Region IX will periodically review these limits during the permit to evaluate the accuracy of the limits. If revisions are necessary, EPA Region IX will make changes according to the authority defined in the Ocean Dumping Regulations at 40 C.F.R. §§ 223.2 through 223.5.

2.4.2. The Permitted Maximum Concentrations, density range and pH range listed above, shall not be exceeded at any time during the term of this permit.

3. SPECIAL CONDITIONS - ANALYSIS OF FISH PROCESSING WASTES

Compliance with the permitted maximum concentrations defined in Special Condition 2.4 shall be determined by monthly monitoring of the waste stored in the permittee's onshore fish processing waste storage tank. DAF sludge, precooker water and press water are stored in the onshore storage tank prior to ocean disposal. Reporting requirements are defined in this section. Any fish processing waste sampling dates shall be scheduled within the first two weeks of the month to allow enough time for laboratory analyses and report writing to comply with Special Condition 3.3.

3.1. Analyses of Fish Processing Wastes

3.1.1. Concentrations or values of the parameters listed in Special Condition 2.4 shall be determined for the waste stream sample from the onshore storage tank during the transfer of these wastes to the disposal vessel's holding tanks. Three samples shall be taken from the onshore storage tank transfer line at 10-minute intervals. These samples shall be composited to produce one sample for analysis. The permittee's samples shall not be combined with fish processing waste from any other permittee. The detection limits specified in Table 4 below shall be used.

Table 4. Physical and Chemical Parameters to be Analyzed from Fish Processing Waste Stored in the Onshore Storage Tank

Parameter	Method Detection Limit
Total Solids	10.0 mg/L
Total Volatile Solids	10.0 mg/L
5-Day BOD	10.0 mg/L
Oil and Grease	10.0 mg/L
Total Phosphorus	1.0 mg/L
Total Nitrogen	1.0 mg/L
Ammonia	1.0 mg/L
pH	0.1 pH units
Density	0.01 g/mL

(Special Conditions 3.1.2, including 3.1.2.1through 3.1.2.4, are hereby deleted, effective October 6, 1995.)

3.1.3 All sampling procedures, analytical protocols, and quality control/quality assurance procedures shall be performed according to guidelines specified by EPA Region IX. The following references shall be used by the permittee:

3.1.3.1. 40 C.F.R. Part 136, EPA Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act;

3.1.3.2. Tetra Tech, Incorporated. 1985. Summary of U.S. EPA-approved Methods, Standard Methods and other Guidance for 301(h) Monitoring Variables. Final program document prepared for the Marine Operations Division, Office of Marine and Estuarine Protection, U.S. Environmental Protection Agency. EPA Contract No. 68-01-693. Tetra Tech, Incorporated, Bellevue, WA; and,

3.1.3.3. Environmental Protection Agency. 1987. Quality Assurance and Quality Control for 301(h) Monitoring Programs: Guidance on Field and Laboratory Methods. Office of Marine and Estuarine Protection, Washington, D.C., EPA 430/9-86-004.

3.2. Analytical Laboratory

3.2.1. Within 30 days of the effective date of this permit, the name and address of the contract laboratory or laboratories and a description of all analytical test procedures and quality assurance/quality control procedures, including detection limits being used, shall be provided for EPA Region IX approval.

FACT SHEET
Calculation of Onshore Fish Waste Storage Tank
Ocean Disposal Permit Limits
For StarKist Samoa (OD 93-01) and
VCS Samoa Packing (OD 93-02)

1. Data collected from the onshore storage tank from September 1993 through August 1994 were used to calculate the revised permit limits. The data for each cannery were evaluated separately.

2. Because variation in these waste streams is such that constituent values are not normally distributed, the data were converted with a logarithmic transformation. The following calculations were then made for each set of data, including mean, standard deviation, and the number of points.

3. Any data values determined to be significantly different from the population of data points by visual inspection of scatter plots, and/or confirmed to be greater than or less than the mean plus or minus 2 standard deviations, were considered to be outliers. Outlier data points were not used in the permit limit calculations.

4. All procedures for calculating permit limits are discussed in Sections 3.1.1 and 3.1.2 (pages 3-1- to 3-9) of EPA's Guidance Document for Ocean Dumping Permit Writers (January 30, 1988).

a. The mean and standard deviation of each physical or chemical parameter were calculated by the following equations:

$$\text{Mean}_x = \frac{\Sigma\, x_i}{N}$$

x_i = each value for the ith constituent
N = the number of data points reported

$$\text{Standard Deviation}_x = \frac{\Sigma\, \{x_i - \text{Mean}_x\}^2}{N - 1}$$

b. The permit limit (Upper Limit) was determined by taking the mean and adding the product of a constant multiplied by the standard deviation.

$$\text{Upper Limit}_x = \text{Mean}_x + (k \times \text{Standard Deviation}_x)$$

k = a constant from Table 3-2 in EPA's 1988 Guidance Document.

c. The constant (k) is based on N and two variables, probability (gamma) and proportion (P), used to compute permit limits. In this case, all limits were calculated with gamma = 0.90 and P = 0.95.

5. The calculated permit limit for the transformed data was then reconverted back to an untransformed value by obtaining the anti-log of the calculated permit limit as follows:

Converted permit limit = E^x

(x = transformed permit limit; E = 2.7183)

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Executive Director
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Allan,

After additional research, I found this authority to be more appropriate.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
Pacific Insular Areas Program
75 Hawthorne Street
San Francisco, CA 94105

March 4, 2002

Phil Thirkell
General Manager
StarKist Samoa, Inc.
P.O. Box 368
Pago Pago, AS 96799

Dear Mr. Thirkell:

I write in response to your request for documentation concerning the status of your existing Marine Protection, Research and Sanctuaries Act § 102 Ocean Dumping Permit, OD93-01.

Pursuant to the Administrative Procedures Act (5 U.S.C. Section 558) your present permit, OD93-01, is still in effect until EPA Region 9 completes its review of your application for a new special ocean dumping permit.

If you have any questions, please contact myself (goldstein.carl@epa.gov, 415-972-3767) or Allan Ota (ota.allan@epa.gov, 415-972-3476).

Sincerely,

Carl L. Goldstein
Program Manager
Pacific Islands Office

cc: ASEPA
Allan Ota, EPA R9

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
Pacific Insular Areas Program
75 Hawthorne Street
San Francisco, CA 94105

March 4, 2002

Herman Gebauer
General Manager
COS Samoa Packing Company
P.O. Box 957
Pago Pago, AS 96799

Dear Mr. Gebauer:

I write in response to your request for documentation concerning the status of your existing Marine Protection, Research and Sanctuaries Act § 102 Ocean Dumping Permit, OD93-02.

Pursuant to the Administrative Procedures Act (5 U.S.C. Section 558), your present permit, OD93-02, is still in effect until EPA Region 9 completes its review of your application for a new special ocean dumping permit.

If you have any questions, please contact myself (goldstein.carl@epa.gov, 415-972-3767) or Allan Ota (ota.allan@epa.gov, 415-972-3476).

Sincerely,

Carl L. Goldstein

Carl L. Goldstein
Program Manager
Pacific Islands Office

cc: ASEPA
Allan Ota, EPA R9
Jim Cox, COSI

Rec'd 7/3/97

JOINT CANNERY OCEAN DUMPING STUDIES

IN

AMERICAN SAMOA

Revised Report

Submitted to

U.S. Environmental Protection Agency, Region 9
American Samoa Environmental Protection Agency

Prepared for

StarKist Samoa
(Permit OD 93-01 Special)
and
VCS Samoa Packing
(Permit OD 93-02 Special)

Prepared by

CH2M HILL

and

gdc

Revised
June 1997

JOINT CANNERY OCEAN DUMPING STUDIES

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gdc

Revised
June 1997

Executive Summary

The ocean dumping permits issued to StarKist Samoa and VCS Samoa Packing require a variety of monitoring and reporting activities. One such activity is a re-evaluation of previous bioassay testing and dispersion modeling reported in previous studies. This activity is described in special condition 3.3.5 of the permits issued to each of the canneries. Ocean monitoring data is also collected as a requirement of the permits (special condition 7). This report presents the results of the bioassay tests and modeling, including evaluation of the monitoring data, done under special condition 3.3.5.

High strength waste, to be disposed of by ocean dumping, was sampled from each cannery as it was transferred to the FV *Tasman Sea*. Samples were taken three times, during various seasons of the year, and shipped to Advanced Biological Testing (ABT) in Tiburon, California. At ABT, bioassays were conducted with a number of test organisms as required by the permits. The methods and test species used were modified in consultation with USEPA as the study progressed. The lowest LC50 recorded in the series of bioassays was 0.12 percent.

The previous modeling was done during the preparation of an Environmental Impact Statement done by U.S. Environmental Protection Agency. This modeling was reviewed and evaluated. CH2M HILL used a different approach to estimate an initial dilution (consisting of an immediate dumping dilution and a nearfield dilution). The two components of the initial dilution were based on propeller theory and the concept of a momentum jet. The farfield dilution was based on the same model (mathematical and physical description) previously used, but implemented with a spreadsheet application.

The results of the model, although considered quite conservative (underpredicting dilution of the waste with receiving water), indicated somewhat higher dilutions at the edge of the dumping zone than previously predicted by the model used in the FEIS. Direct comparisons cannot be made since the vessel in use is not the same. However, predictions for the worst case, corresponding to average ocean currents, in the summer, and at maximum discharge rate, indicate a concentration at the edge of the dumping zone that is 0.0021·(LC50) described above.

Ocean monitoring data collected as a requirement of the permits includes analysis of the high strength waste material prior to disposal and receiving water monitoring. These data were examined and evaluated for consistency with the model predictions. Although the data collection is not specifically designed for model verification, the evaluation conducted supports, and is consistent with, the model predictions. The available data indicates that the wastefield is sufficiently diluted and mixed within the designated dumping zone to eliminate any effects outside the immediate disposal area.

The original report on these studies was reviewed by Dr. Mohamed A. Abdelrhman of the Environmental Protection Agency's Research Laboratory in Narragansett, Rhode Island. Dr. Abdelrhman extensively reviewed the modeling section of the original report. The revised report was prepared in response to his suggestions and comments. Although, no revisions were incorporated into those parts of the report concerning the bioassay tests and results, the entire report was reissued for the convenience of keeping the entire set of study results under one cover.

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1. Introduction

The Regional Administrator of EPA Region IX determined that ocean disposal of fish processing wastes off American Samoa meets EPA's ocean dumping criteria (40 CFR Parts 227 and 228). Based on this determination EPA issued special ocean dumping permits to StarKist Samoa, Inc. and VCS Samoa Packing, Inc. on September 1, 1993. Special condition 3.3.5 of both permits requires bioassay testing of the waste from each cannery and a re-evaluation of the model previously used to predict concentrations of fish processing wastes disposed of at the designated disposal site. A copy of this special condition is provided in Appendix 1. This section of the report describes the purpose of the report, presents pertinent background information, and describes the organization of the materials presented in subsequent sections.

Purpose

The purpose of this report is to document the results of the bioassay and modeling studies required by the special ocean dumping permits under special condition 3.3.5. StarKist Samoa (Permit No. OD 93-1 Special) and VCS Samoa Packing (Permit No. OD 93-01 Special) were required to conduct and submit the results of toxicity tests using fish processing wastes generated at the permittees' American Samoa tuna processing and packing plants. The wastes tested were DAF (dissolved-air flotation waster water treatment processes) sludge and other high strength waste streams that are barged to sea for disposal at the permitted dump site. The report describes the methods and results of the bioassay tests.

Permit condition 3.3.5 requires that the bioassay results be used to re-evaluate the previous model predictions of dispersion of the plume created by dumping fish processing wastes at sea. The model re-evaluation was conducted by: evaluation of the previous model for application to the current disposal operations, development and application of a revised more sophisticated model(s), and evaluation of available field data for consistency with model predictions. The report describes these modeling exercises and the results of the model predictions.

Background

StarKist Samoa and VCS Samoa Packing (the canneries) began ocean disposal of DAF sludge off the south coast of Tutuila Island in December of 1980 (Permit Number: OD 79-01/02 Special). A field study of the fate and transport of the waste was described by Soule and Oguri (1983). In 1990 the disposal site was moved further offshore into deeper water based on an Environmental Impact Statement done by EPA (1989) and a supplementary mathematical model study (SOS, 1990). The existing permit was issued for the deep water site in 1993 (effective date of 1 September 1993 - expiration date 31 August 1996).

The existing permits allow disposal at the deep water site mentioned above is located approximately 5.16 nautical miles offshore in a water depth of about 9000 feet. The dump site is a circle of 1.5 nautical mile radius. The permit allows the disposal of up to a total of 200,000 gallons per day including: DAF sludge (60,000 gallons per day) and high strength process stream wastes (100,000 gallons per day of precooker water and 40,000 gallons per day of press water). The concentrations of various physical and chemical parameters are limited in the permits. Special conditions in the permits require monitoring and analysis of the fish processing wastes to be disposed of, monitoring of vessel operations and position, notices to regulatory agencies, receiving water monitoring, and biological community observations and reporting.

This report was prepared under special condition 3.3.5 as discussed above and reproduced in Appendix 1. A draft study plan was prepared and submitted to USEPA and ASEPA in November 1993 (CH2M HILL, 1993). Comments were received from EPA on the study plan in a letter dated 10 December 1993. These comments concerned details of the bioassay sample collection, shipping, and certain protocols of the bioassay tests. The comments were easily accommodated and the draft study plan was not revised. The final study plan consists of the Draft Study Plan and the EPA comments which are included as Appendix 2. In addition, some changes were made to the bioassay test protocols and procedures, with the concurrence of EPA. These changes are documented in descriptions of the bioassay tests below, and in the following section of the report.

Scope of Report

The special permit condition addresses two distinct efforts: bioassay testing and model re-evaluation. Although the results of the bioassay testing can be used with the model results to predict the potential for toxicity, the two parts of the study are quite different and are best described independently. Therefore, this report is presented in four main parts: a description of the bioassay test results, a description of the results of the modeling, an evaluation of the available field monitoring data with comparisons to the model predictions, and a final section presenting conclusions and recommendations. References are provided and additional detailed information is provided in Appendices.

For the bioassay tests, this report basically summarizes the previous memoranda sent to EPA after each of the sampling and testing episodes. For the modeling portion of the studies, the report extends the memorandum previously sent to EPA summarizing the results and provides detailed descriptions of the modeling study to a level sufficient to allow independent review of the modeling as well as responding to EPA comments on the previously reported modeling results. The interpretation of the modeling and field data evaluation results, incorporating the bioassay information, is formalized in this report.

2. Bioassay Testing

Bioassay tests were conducted as required in the permits with modifications as approved by EPA and documented below. General guidance for these tests was provided by USEPA (1991), ASTM (1992), and the EPA/COE "Green Book" (1991). Specific guidance for performing biological-effects tests for Ocean Disposal permits are outlined in Part III, Section 11 of the Green Book; *Evaluation of Dredged Material Proposed for Ocean Disposal: Testing Manual* (EPA and COE, 1991). However, the fish processing wastes to be disposed under the permits are not similar to solid dredged materials. The high strength waste materials are mostly positively to neutrally buoyant liquid phase wastes. The physical and chemical nature of the wastes required that the tests be conducted as effluent tests, which was agreed to by EPA (see Appendix 2). The following sections briefly summarize the methodology for sampling and testing, and report the results of the tests. More detail is given in the Study Plan (Appendix 2) and the standard operating procedures (SOP) for the collection of the high strength wastes (HSW) (Appendix 2). Approved changes made to the permit conditions and study plan as the study proceeded are described and documented below.

HSW Sampling Procedures

High strength waste samples were collected at each cannery from the existing sampling ports in the storage tank transfer lines. Three samples were taken at 10 minute intervals while waste was being transferred from the storage tanks to the barge. Samples for the bioassay tests were composited from the three discrete samples. Waste from each cannery was sampled and tested separately. Detailed procedures used for sampling, sample handling, and shipping are included in the SOP referenced above. The sampling periods were modified from the original sampling plan as follows:

- Originally scheduled 30 November 1993: Sampled 16 February 1994
- Originally scheduled 28 February 1994: Sampled 20 October 1994
- Originally scheduled May 31, 1994: Sampled 23 June 1995

Changes in sampling and testing periods were approved by EPA as described in the correspondence included in Appendix 4.

Test Species

The permit condition requires toxicity testing with three species selected from three groups listed in section 3.3.5 of the permit. The study plan initially set up a proposal that the tests be conducted with the pacific mysid shrimp (*Holmesimysis costata*) juveniles, pacific sanddab (*Citharichthys stigmaeus*) juveniles, and purple sea urchin (*Strongylocentrotus purpuratus*) larvae. The rational for this selection is provided in the Study Plan (Appendix 2). It was further proposed that, if necessary, *Mytilus* sp. (mussels) would be used as a backup species to the sea urchin and white shrimp (*Paneaus vannami*) would be used as a back-up test species for the mysid shrimp should the primary test species be unavailable at the time of the bioassays.

In their comments on the study plan (see Appendix 2) EPA recommended replacing *Holmesimysis costata* with *Mysidopis bahia* which was done. For the first of the three required testing episodes both *Mytilus edulis* (blue mussel) and *Strongylocentrotus purpuratus* were tested, and, as described in more detail below, *Mytilus* was selected for the following tests. Because of difficulties in spawning *Mytilus* was not tested during the third test.

Testing Methodology

The testing methodologies used for acclimation and holding of test organisms, sample preparation, and experimental conditions and procedures, QA/QC, and data analysis are described in the Study Plan (Appendix 2) and in the detailed laboratory reports (Appendix 5). However, one aspect of the testing procedures, the potential for and handling of high IDOD, deserves special note. Initial dissolved oxygen demand (IDOD) has been determined to be a problem with cannery effluent and high strength waste streams. Preliminary IDOD measurements were done at the canneries in October of 1993. The results indicate a typical IDOD demand within the first 15 minutes and a second high demand that occurs between 10 and 14 hours. The second demand can, if not anticipated, compromise and even make useless a bioassay test in progress. The results of these IDOD measurements were used for guidance in determining sample dissolved oxygen (DO) conditions and aeration procedures required for the bioassays in this study. Advanced Biological Testing of Tiburon, California, performed the bioassays and was able to anticipate and account for this aspect of the tuna cannery wastes.

Results of the Bioassay Tests

Three sets of bioassay tests were conducted on the HSW for each cannery. The results of these tests were reported to USEPA and ASEPA in separate memoranda for each testing episode. Modifications and changes to the original study plan were made for each of the tests as documented in the memoranda and in communications with EPA provided in Appendix 4. Each of these testing episodes is briefly reviewed below and the results of all of the tests are given in Table 2.1.

First Set of Bioassay Tests

Sampling for the first bioassays tests was done in February 1994 (see EPA comments on the Draft Study Plan in Appendix 2). Detailed methods and results of the tests are presented in the attached: *"Results of a Bioassay Conducted on Two High Strength Waste Samples from the Van Camp and StarKist Tuna Canneries in American Samoa"* prepared by Advanced Biological Testing Inc., Tiburon, California, and provided in Appendix 5. Acute effluent bioassays were conducted on four species including the three listed in the study plan plus one of the alternates. The species used were *Mysidopsis bahia* (mysid shrimp) juveniles, *Mytilus edulis* (blue mussel) larvae, *Strongylocentrotus purpuratus* (purple sea urchin) larvae, and *Citharichthys stigmaeus* (speckled sanddab) juveniles. The results of these bioassays are summarized in the Table 2.1 below and were provided to EPA as a memorandum to the American Samoa Project Manager (CH2M HILL, 1994).

Based on the results of the first set bioassays, CH2M HILL recommended two changes to the HSW bioassay protocol as follows:

- Reduction of the upper end of the HSW concentration series for all bioassays to a maximum of 3.0 percent. This was done for the first set of tests after discussions with EPA as reported in the laboratory report (Appendix 5). No additional information is required at concentrations greater than 3.0 percent and reducing the maximum concentrations reduces the amount of HSW that needs to be sampled and shipped. We recommended a series of concentrations for the bioassays of 3.0%, 1.5%, 0.8%, 0.2%, 0.1%, and 0.05%.

- Continue running bioassays with *Mytilus edulis* while monitoring the effects of aeration on organism mortality and drop the use of *Strongylocentrotus purpuratus* larvae as test organisms for the HSW. This recommendation was made for the following reasons:

  - Special Condition 3.3.5 of the permits required only three organisms be tested; one organism each out of three specified groups. *Mysidopsis bahia* and *Citharichthys stigmaeus* satisfy the requirements for Groups 2 and 3. Group 1 contains larval stages of both bivalves and echinoderms and running just *Mytilus edulis* should satisfy this requirement.

  - Because of the high oxygen demand of the effluent, all test containers required aeration throughout the tests to maintain adequate oxygen concentrations for the test organisms. Aerating the chambers using *Mytilus edulis* and *Strongylocentrotus purpuratus* larvae as bioassay test organisms gives problematic results. Aeration is standard protocol for bioassays on fish and invertebrates when oxygen levels fall below 40% of saturation, but is not standard protocol for bioassays on larval bivalves and echinoderms. The effects of aerating the water on the survival of these organisms is not known. Because the *Mytilus edulis* bioassays are only run for two days (vs. four for the *Strongylocentrotus purpuratus*) the organisms are exposed for half the time and the effects of aeration may be reduced.

  - The mortality of the control group was substantial for the echinoderms and is unacceptable according to protocol. The cause of the high mortality in the control is not known.

The results and methods for the first set of tests and the recommendations described above were reviewed and accepted by EPA as documented in the attached communications dated 29 August 1994 (Appendix 4). The recommendation for reducing the maximum concentrations of the samples was accepted by U.S. EPA and, after consultation between Advanced Biological Testing and EPA, new test concentrations were established for the mysid, mussel, and sanddab tests of 2.0, 1.0, 0.5, 0.25, 0.125, and 0.06% as a volume dilution in 30 ppt sea water. The recommendation for dropping the urchin test was accepted by U.S. EPA. The mussel test was continued to investigate the effects of aeration as described below. Other recommendations were made by EPA in the letter, which were adopted as described below and in the detailed laboratory reports.

Second Set of Bioassay Tests

The results of the second set of tests are presented in the attached: "*Results of a Bioassay Conducted on Two High Strength Waste Samples from the Van Camp and StarKist Tuna Canneries in American Samoa*" prepared by Advanced Biological Testing Inc. (ABT), Tiburon, California, (Appendix 6). The second sampling was conducted in October 1994. Acute effluent bioassays were conducted on *Mysidopsis bahia* (mysid shrimp) juveniles, *Mytilus edulis* (blue mussel) larvae, and *Citharichthys stigmaeus* (speckled sanddab) juveniles. The results of these bioassays are summarized in the Table 2.1 below and were provided to EPA as a memorandum to the American Samoa Project Manager (CH2M HILL, 1995a).

In the first test described above it was determined that due to the high oxygen demand, including a high immediate oxygen demand, of the effluent all test containers required aeration throughout the tests to maintain adequate oxygen concentrations. Aeration is standard protocol for bioassays on fish and invertebrates when oxygen levels fall below 40% of saturation, but is not standard protocol for bioassays on larval bivalves and echinoderms. Therefore, aerating the chambers containing *Mytilus edulis* may give problematic results. In the second test gentle aeration was initiated on Day 0, and continued for the duration of the tests. To assess the effects of aeration, an aeration control for the mussel test was run simultaneously. No statistical differences were observed between aerated and unaerated controls. It was recommended that this type of aeration continue to be used with the mussel test.

Third Set of Bioassay Tests

The results of the third set of tests are presented in the attached: "*Results of a Bioassay Conducted on Two High Strength Waste Samples from the Van Camp and StarKist Tuna Canneries in American Samoa*" prepared by Advanced Biological Testing Inc. (ABT), Tiburon, California, (Appendix 7). The third sampling was conducted in June 1995 this test was delayed to get better seasonal coverage with the concurrence of USEPA (see Appendix 4).

Acute effluent bioassays were conducted on *Mysidopsis bahia* (mysid shrimp) juveniles and *Citharichthys stigmaeus* (speckled sanddab) juveniles using HSW collected separately from the StarKist Samoa and VCS Samoa Packing canneries in Pago Pago Harbor, American Samoa. The results of these bioassays are summarized in Table 2.1 below and were provided to EPA as a memorandum to the American Samoa Project Manager (CH2M HILL, 1995b). For this sampling *Mytilus edulis* (blue mussel) larvae were unavailable as the mussels were spawning. The U.S. EPA reviewed the problem of the mussel spawning and waived the requirement to conduct the bioassay test on the mussel larvae for this sampling period (see Appendix 4).

Summary of Results of the Bioassay Tests

Table 2.1 summarizes the results of the bioassay tests. As noted above, each of the testing episodes is reported on in detail in Appendices 5, 6, and 7.

Table 2.1
Summary of High Strength Waste Bioassay Results.

Test Organism	Endpoint	StarKist Samoa			VCS Samoa Packing		
		2/94	10/94	6/95	2/94	10/94	6/95
Citharichthys stigmaeus (sanddab)	LC_{50}	0.27%	0.35%	0.396%	0.59%	0.37%	0.626%
	NOEC	0.20%	0.25%	0.25%	0.40%	0.25%	0.25%
	LOEC	0.40%	0.50%	0.50%	0.80%	0.50%	0.50%
Mysidopsis bahia (mysid shrimp)	LC_{50}	0.12%	1.16%	0.675%	0.59%	0.79%	0.625%
	NOEC	0.05%	0.50%	0.125%	0.05%	0.50%	0.25%
	LOEC	0.10%	1.00%	0.25%	0.10%	1.00%	0.50%
Mytilus edulis (blue mussel)	LC_{50}	>1.20%	>2.0%	[2]	>1.20%	>0.20%	[2]
	IC_{50}	<0.08%	0.10%	[2]	<0.08%	0.18%	[2]
Strongylocentrotus pupuratus (urchin)[1]	LC_{50}	1.20%	-	-	1.20%	-	-
	IC_{50}	<0.08%	-	-	0.10%	-	-

1 Urchin test not conducted in second and third test periods (w/concurrence of U.S. EPA).
2 Mussel larvae not available for test, requirement waived by U.S. EPA for this test.

3. Model Evaluation

This section describes the re-evaluation of certain previous model predictions of dispersion of the plume created by dumping fish processing wastes at sea. The previous predictions are presented in Appendix B of the FEIS (EPA, 1989) and in a supplementary study (SOS, 1990). This model is referred to as the "FEIS model" throughout this section of the report. Appendix B of the FEIS is reproduced in Appendix 8 of this report for convenience. The model re-evaluation was conducted in four phases as describe below. The steps were:

- The previous model, as described in the 1989 FEIS, was used. This model was reformulated and implemented as an Excel 5.0 spreadsheet and the results of this reformulation checked against the previous (FEIS) results.
- The input data and assumptions used in the FEIS model were examined and evaluated. Critical parameters, including assumed values for diffusion coefficients, initial dilution, and ambient conditions were reviewed. The appropriateness and applicability of previously assumed values are evaluated and discussed.
- A somewhat different approach for the initial dilution as the waste is pumped into the propeller slipstream was developed. The objective of the new approach for initial dilution with a different model is intended to account for changes in vessel characteristics and operational methods and to develop more representative overall model predictions. Model predictions were developed for the current disposal operations using the new initial dilution procedures and the reformulated farfield model.
- The model predictions are then used by applying the new bioassay test results presented in the previous section and this evaluation is provided in the conclusions and recommendations section (Section 5) of the report below.

A summary of the model evaluation was provided to USEPA and ASEPA in a memorandum prepared by CH2M HILL (1995c). The descriptions below expand and further document the summary previously provided, and include information responding to comments on the previous (July 1996) version of this report.

Previous Model Formulation

The previous model (FEIS model, EPA 1989), is based on an approach originally developed by Brooks (1960), and has been found by the authors of this report to be typically very conservative (overpredicts concentrations) in similar applications. Other assumptions in the model are also considered to be conservative as described in the discussions below. The term conservative, as used in this section of the report and when applied to assumptions or methodology, always indicates that the expected result is most likely to be an <u>overstatement of concentration</u> (waste) or an <u>understatement of dilution</u> within the temporal and spatial context of the statement. The results of the model are presented in terms of dilution (or concentration) of fish processing waste versus distance from the point of introduction into the receiving water. Based on the results of the bioassay tests, the distance from the dump site where the effluent is diluted to the limiting permissible concentration (LPC) level can be determined.

The FEIS model formulation, based on the approach presented by Brooks (1960), is essentially the same basic model as CDIFF (Yearsley, 1989). The formulation developed by Brooks calculates the lateral diffusion of a discharge plume as it is advected in the longitudinal direction and does not account for longitudinal dispersion. As initially developed by Brooks, the approach does not account for vertical diffusion, does not provide for the settlement of negatively buoyant constituents in the plume, and does not account for the dispersion of a positively buoyant plume or positively buoyant components of the discharged material. In addition the model, as implemented in the FEIS, assumes a line source of constant strength. The basic model formulation is given by a dimensionless expression of the form:

$$\frac{C_{\max}}{C_o} = \frac{H/4}{\sqrt{2K_v t + \frac{H^2}{16}}}\, erf\left[\sqrt{\frac{1.5}{\left(1+\frac{8At}{L^{(2/3)}}\right)^3 - 1}}\right]$$

where C_{max}/C_0 is the ratio of the centerline plume concentration to the initial concentration, L is a length parameter, A is a horizontal dissipation coefficient equal to the horizontal turbulent diffusion coefficient (ε) divided by $L^{4/3}$ with units of $[L]^{2/3}/[t]$, *erf* indicates the error function, and all other variables and parameters are discussed below (and detailed descriptions can be found in Appendix 8 and associated references).

The FEIS model provides for a settling velocity by redefining the longitudinal coordinate at a downward angle defined by the relationship between the longitudinal current speed and assumed vertical settling velocity such that:

$$x' = x \cdot \cos(\theta)$$

where

$\theta = \tan^{-1}(u/w_S)$

u = ambient horizontal, longitudinal velocity

w_S = settling velocity

x = horizontal longitudinal coordinate given by $t \cdot u$ (t is time)

x' = redefined longitudinal coordinate

The FEIS model also accounts for vertical diffusion by applying a non-dimensional concentration reduction factor based on a Fickian diffusion coefficient (K_v). This factor is applied to the calculated centerline concentration $(C_{max})_{CL}$ to obtain an adjusted value $(C_{max})_{ADJ\text{-}CL}$ accounting for vertical diffusion as:

$$(C_{max})_{ADJ\text{-}CL} = (C_{max})_{CL} \cdot \{(H/4) / (2 \cdot K_v \cdot t + H^2/16)^{0.5}\}$$

where H is the initial vertical plume dimension defined as the vertical extent of the plume at the beginning of initial dilution, with H/4 as the distance from the surface to the point of C_{max}, and is a vertical dimension used to account for the effect of vertical diffusion in the farfield model. The relationship of H to the plume geometry is discussed further below. Travel time along the plume trajectory is represented by t. The two changes described above are the only modifications made to the original Brooks formulation. The FEIS model input variables include ambient current speed, initial dilution, settling velocity, and initial plume dimensions (as characterized by L).

Based on the descriptions in the 1989 FEIS, the model was reproduced and tested by CH2M HILL. The model results for all cases were not able to be exactly reproduced and there may be some errors, simplifications, or inconsistencies in the original formulation. However, these errors are not "fatal" and generally not significant. In fact, the differences noted below may be simply caused by differences in the numerical formulation between the two approaches. The maximum disagreement between results from the CH2M HILL formulation and the initial FEIS formulation of the model are on the order of 10 percent, and typically much smaller. Tables 3.1 and 3.2 show the comparison of published predictions for the FEIS model and the CH2M HILL spreadsheet model predictions based on the same set of differential equations. The FEIS model predictions appear to have been reasonable, and probably conservative, for the development of the ocean dumping siting and operational procedures.

Evaluation of the Previous Model

The FEIS model is evaluated below on the basis of the assumptions and input used to develop and implement the model. These factors fall into three categories which are examined to determine the general and specific applicability of the model approach and the model formulation and implementation, respectively. The three categories considered are: [1] assumptions involved in the basic formulation of the model involving the fundamental physics and mathematics used; [2] the assumptions and methodology used to chose the magnitudes of the variables describing the important physical processes; and [3] the values used for the description of ambient conditions and characteristics of the waste material. Each of these categories of model assumptions and input was examined and re-evaluated, as discussed in more detail below. In addition to the direct re-evaluation of the model assumptions and inputs, the sensitivity of the model to important variables was assessed.

The FEIS model is based on differential equations that consider lateral and vertical diffusion. Longitudinal diffusion (in the direction of the ambient current) is neglected because of its relative magnitude which is small compared to other terms. This assumption is well founded for the current patterns observed and anticipated in the disposal area. The actual equations were developed by Brooks (1960) and can be rearranged to resemble the classical error function by adding an exponential decay term. For open ocean applications the diffusivity is expressed in terms of a 4/3 power relationship, which is a widely accepted approach (see for example Fischer et al. (1979). The affect of vertical diffusion is assumed to be Fickian. An appropriate term is multiplied with the error function to predict total diffusion from both lateral and vertical components. The approach taken in the FEIS model appears reasonable for application to the farfield following the initial development of the waste plume. It is noted that the model as reproduced by CH2M HILL on a spreadsheet application uses a numerical approximation to the error function (with an associated error of less than $2 \cdot 10^{-7}$). Differences between the FEIS model and the CH2M HILL implementation of that model described above may be explained, at least in part, by differences in the approximations used for the error function.

The vertical diffusion in the FEIS model is dependent on a coefficient of vertical diffusion which is assumed constant during the winter and depth dependent during the summer (as reflected in the results in Tables 3.1 and 3.2). The reasoning behind this approach is based on the seasonal existence of a thermocline in the summer. The vertical diffusion coefficient is the only depth varying parameter in the governing equations used in the FEIS model.

In the FEIS model the initial plume depth is take to be H/4, where the dimension H is obtained from the equation,

$$U \cdot L \cdot H \cdot C_0 = Q$$

where,

U = ambient velocity,
L = a characteristic length parameter,
C_0 = the initial waste concentration (at the beginning of farfield dilution),

and

Q = the flow rate of the waste stream from the barge.

The width of the initial plume is taken to be twice the turning radius of the dumping vessel. A characteristic length of the vessel, set equal to the geometric mean of the half beam, and the draft of the vessel, is the length parameter used in the equation to calculate initial concentration. The FEIS modeling report does not clearly justify this assumption. One of the suggested modifications to the model, as described below, is a better description of the initial dilution of the plume. The formulation used in the FEIS model is not particularly well founded in physics, although it appears to be quite conservative in terms of the formulation of initial dilution, particularly for the vessel and disposal method currently being used (based on the discussions below) and is acceptable from a regulatory basis where any uncertainty should be on the conservative side.

The FEIS model makes several assumptions concerning the initial dumping of the waste. First, the relative velocity term that is used in the equation for calculating the initial concentration, C_0, is simply the speed of the vessel (over the bottom) where:

$$C_0 = Q/(1.814 \cdot \pi \cdot R^2 \cdot V)$$

with

Q = to the discharge rate of waste

R = a characteristic length of the body as described in Appendix 8

V = relative speed of the ship to the receiving water.

It is noted that C_0 is a dimensionless concentration, or the constant 1.814 has dimensions of inverse concentration. The FEIS is not clear on this point and the original references must be reviewed to clarify this point. However, the specification and use of C_0 is the major difference between the FEIS model and the revised model calculations presented below, and the FEIS specification of C_0 is not used further in this study.

In the FEIS specification of C_0, the assumption is made that as the ship circles in a constant ambient current, the net effect of the ocean current is canceled out. In addition, the flow value used is a time average which changes in response to relative velocity. Thus, it may be considered that there is no net effect on initial concentration because the calculation of C_0 involves flow in the numerator and relative velocity in the denominator. Regardless of the rationale, the ambient current speed is at least an order of magnitude smaller than the vessel speed, thus the use of vessel speed for relative velocity is a reasonable assumption.

Assumptions used, once the initial dumping has occurred, include maintaining the majority of the plume near the surface, surface waves can be disregarded, the plume does not reach the 120 fathom contour, and the pumping rate mixes the flow without altering the wake pattern of the vessel. All of these assumptions are physically reasonable or, if over-simplified, appear to result in a conservative approach (dilution will be under predicted since the effects would be generally to confine the wastefield to a region that might be smaller than would actually occur).

Three areas for improvement in the FEIS model have been identified as a result of the evaluation summarized above. One of these involves the modeling of the initial dilution processes which determines the initial concentration used as an initial condition in the farfield model. The other two areas involve the actual formulation of the farfield model and are discussed below. These problems with model formulation probably explain, at least in part, the differences in predictions of the FEIS model and CH2M HILL's application of that model as discussed above. No reason to significantly modify, or replace, the farfield model (essentially the FEIS model) has been identified other than to address the points discussed below. However, it is believed that a more realistic approach to initial dilution is available and has been incorporated into the overall model, as described below in the following section on revised model predictions.

In the FEIS modeling report, the values given for the vertical diffusion coefficient, K_V, are based on seasonal variability. As described above, winter values are held constant. Summer values are presented for depth ranges of 100 meter intervals: 0 to 100 meters, 100 to 200 meters, and below 200 meters. K_V is the only depth dependent variable in the model. The results shown in Appendix B of the FEIS (Appendix 8 of this report; see page B-18) show different values of C_{MAX}/C_0 for two fall velocities of 0.1 cm/sec and 0.01 cm/sec for, and only for, the case of 0.2 knot ambient current (values are the same for the two fall velocities for other ambient currents). Since all depths are less than 100 meters for these two cases, and K_V is constant, the differences are curious.

For the reason described above, CH2M HILL's implementation of the FEIS model could not replicate the results for the 0.2 knot current speed (see Table 3.2). In addition, the CH2M HILL implementation could not reproduce the deep (fall velocity of 1 cm/sec) case within an accuracy of up to about 10 percent (see Table 3.2). The latter discrepancy may well be related to the other problems mentioned above. The original model code was not obtained, so a definitive answer concerning these problems was not available. However, the differences are not particularly troublesome, given the nature of the model to begin with, as discussed above, and do not compromise the results of the original study in any way. Overall agreement remains very good.

Examination of the characteristics of the HSW indicates that it will generally remain near the surface as a neutrally buoyant plume and the farfield model does not need to consider a negatively buoyant fraction. Thus, in the developments below, CH2M HILL considered only a surface plume and did not vary K_V with depth (but only with season).

Another possible problem with the implementation of the FEIS model occurs when the two waste pumping rates are considered. The modeling report indicates that the discharge rate from the vessel is 140 gpm per knot of vessel speed, up to 10 knots. Initial concentration of waste is a function of flow divided by relative velocity. This implies that the initial concentration will remain about the same, particularly since the vessel speed is taken as the relative velocity as discussed above. However, the initial concentrations reported are 0.000222 and 0.000621, for a discharge of 500 gpm and 1400 gpm, respectively. It appears that the vessel speed was not varied with discharge rate. Again, this leads to conservative predictions, as the initial concentration for the higher discharge rate is over-stated. The model as implemented by CH2M HILL for the current disposal operations did vary vessel speed with discharge.

The FEIS model was developed based on a different vessel, using a different operational mode of discharge, than currently used. CH2M HILL has considered the current vessel and operational procedures. Based on the evaluation of the existing model, including the possible errors mentioned above and the changes in discharge operation, a revised model for the initial dilution process (prediction of initial concentration) is considered appropriate. The revisions should account for both the discharge of the material directly between the two counter rotating propellers of the FV *Tasman Sea* and a more sophisticated approach to dilution in the propeller slip stream. Farfield dilution can then be calculated following methods similar to those used previously, and using CH2M HILL's spreadsheet formulation of the initial FEIS farfield model (and applying the changes described above to the original FEIS formulation).

Revised Model Formulation and Predictions

An independent model was formulated and used to evaluate the dispersion of waste discharged from the barge. The purpose of this model is to provide an alternative to more realistically describe the fate and transport of the discharge. The primary differences between the FEIS and the CH2M HILL model approaches are the use of initial dilutions as determined based on the dynamics of the propeller slipstream and the use of characteristics of the current dumping vessel.

The new model developed by CH2M HILL consists of three parts:

- Dumping dilution - results from the initial discharge into the propeller wash and is numerically equivalent to the propeller discharge rate plus the waste discharge rate divided by the waste discharge rate:

- Nearfield Dilution - results from the entrainment of sea water into the momentum jet from the propellers which contains the waste discharge

- Farfield Dilution - results from the subsequent dilution of the plume and is essentially the same model used previously with the differences described above.

The major difference between the previous (FEIS) and current approach is the development of initial concentration (C_0 in the FEIS model) to be used in translating the farfield (Brooks' formulation) calculations into actual concentrations or total dilutions. The combination of dumping dilution and nearfield dilution is essentially a replacement for the specification of C_0 previously used in the FEIS. The formulation and predictions for each of the three parts of the model are described below. The transition between the nearfield and farfield is also discussed. Figure 3.1 is a schematic of the various regions modeled and discussed below.

The vessel characteristics assumed for the models are based on the known vessel characteristics as described by the vessel operator and are as follows:

Number of Propellers:	2 - counter rotating (to CL from above)
Propeller Diameter:	4 feet
Propeller Spacing:	15 feet on center
RPM/Speed:	500 rpm at slow ahead (6 knots - stabilized)
	700 rpm at 8 knots
	900 rpm at 10 to 11 knots
Draft:	12 feet (propeller CL at 10 feet)
Beam:	38 feet
Discharge Pipe:	6 in diameter to CL of propeller pair

Dumping Dilution

The dumping dilution is the immediate dilution realized as the discharge pipe releases waste at the stern of the vessel between the two counter-rotating propellers (Figure 3.2 illustrates the process schematically). It is calculated as the propeller discharge rate (water flow through the propeller) plus the waste discharge rate divided by the waste discharge rate:

$$DD = \frac{Q_p + Q_e}{Q_e}$$

Dumping dilution is equivalent to the ratio of concentration immediately after injection of the waste to the initial concentration. The discharge rate through the propeller can be calculated using propeller theory. The most direct calculation is based on the momentum theory of propellers and a practical explanation and description, with further references, can be found in Liou and Herbich (1976). CH2M HILL project staff have used this approach to calculate induced water speeds by ferries in Puget Sound (Washington), barges on the Cohansey River (New Jersey) to evaluate subsequent induced sediment transport.

The velocity V_0 (in knots) through the propeller immediately behind the vessel is given by:

$$V_0 = (1+b)\cdot V_A$$

where

V_A is the ship speed (knots),

and

$b = 2a = 2\cdot(1/\eta_1 - 1)$, with η_1 = ideal efficiency = $2/\ (1+(C_T+1)^{1/2})$.

The term C_T is the dimensionless thrust loading coefficient,

$$C_T = T/(0.5 \cdot \rho \cdot A_0 \cdot (V_A)^2)$$

where

T = thrust developed = $K_T \cdot \rho \cdot n^2 \cdot D^4/3600$ (units of force - knots·slugs·rpm)
K_T = the thrust coefficient described below (knots/(feet·rpm))
ρ= density of water (1.99 slugs per cubic foot)
A_0 = disk area of propeller, $\pi/4 \cdot D^2$ (square feet)
n = rpm of propeller (revolutions per minute)
D = diameter of propeller (feet).

The term K_T is the thrust coefficient which is a function of the propeller-characteristic curve and is approximated as a function of the speed coefficient, J_T, as described in Liou and Herbich (1976):

$$K_T = 0.48 - 0.41 \cdot J_T$$

and

$$J_T = 101.33 \cdot V_A/(n \cdot D)$$

where variables are as defined above.

From the above velocity V_0 and the propeller area A_0, the flow through the propeller (Q_0) can be calculated as $V_0 \cdot A_0$.

Application of the above relationships, using the vessel characteristics provided, results in the following immediate dumping dilutions: 400:1 and 367:1 for discharge flows of 1400 gpm and 840 gpm, respectively, and for a single propeller stream. For the dual propellers the dumping dilutions become 800:1 and 733:1 for the same flows, since half the effluent is considered entrained behind each propeller. The vessel is assumed to be traveling at 10 knots and at 6 knots for discharge rates of 1400 gpm and 840 gpm, respectively. This is the reasonable range of speeds the vessel can make in the open sea. These flows correspond to winter time (June 1 through November 30) permitted disposal rates of 140 gpm/knot with a maximum of 10 knots. The summer permitted limit is at 120 gpm/knot with a maximum of 10 knots and the dilutions would be approximately 1.17 times those listed above. Calculations for dumping dilutions are summarized in Table 3-3 and 3-4.

Nearfield Dilution

The use of propeller theory to determine the immediate initial dilution partially replaces the initial dilution (or concentration, C_0) used in the FEIS model. As described above, CH2M HILL also applied another model between the initial dilution and the farfield predictions based on the Brooks method. This was done to account for the rapid mixing within the propeller slipstream. The model assumes that all of the waste discharged is entrained in the slipstream. This is considered a very good assumption, and, based on the disposal method, it is difficult to see how the situation could be otherwise.

The nearfield approach used (Sobey, 1994) considers conservation of momentum in a round momentum jet (the propeller slip stream). The centerline velocity, U_{CL}, and flow at any distance x from the point of discharge, Q_X, are given by:

$$U_{CL} = \frac{1}{\alpha x}\sqrt{\frac{K_o}{2\pi I_2}}$$

and

$$Q_x = \alpha x I_1\sqrt{\frac{2\pi K_o}{I_2}}$$

where

$K_0 = Q_0 \cdot V_0$

with subscript $_0$ indicating initial conditions at the propeller,

$Q_0 = V_0 \cdot A_0$

where V_0 is the velocity of the jet through the propeller and is taken relative to the ambient fluid and A_0 is the propeller area,

$I_1 = 0.72$,

$I_2 = 0.36$,

and

$\alpha = 0.096$.

For the above two equations, consistent units must be used since all constants are unitless. For example, distance in feet, velocity in feet per second, and flow in cubic feet per second are consistent units.

Nearfield dilution (D_N) at a distance x from the point of discharge is given by Q_X/Q_0. The dilution as a function of x will remain the same for various vessel speeds, since the initial flow through the propeller changes in direct response to vessel speed. This apparently counter-intuitive result is shown as follows:

$$D_N = \frac{Q_x}{Q_0} = \frac{\alpha x I_1\sqrt{\frac{2\pi K_0}{I_2}}}{A_0 V_0}$$

but

$$K_0 = Q_0 V_0$$

and

$$Q_0 = A_0 V_0$$

so D_N is not a function of V_0; it is only a function of distance (x) for a given A_0.

The momentum theory for propellers also provides a means to calculate velocity and is given in Liou and Herbich (1976):

$$V(r,x) = (V_0 \cdot D_0 / x) \cdot 10^{\varepsilon}$$

where

$\varepsilon = 0.79 - 33 \cdot (r/x)^2$
r = distance in the radial direction

and on the centerline (r = 0):

$$V(x) = U_{CL} = (V_0 \cdot D_0 / x) \cdot 6.17.$$

As a check the calculations for velocity were done using both equations for centerline velocity and agreement was excellent when calculated on the same basis. Calculations for nearfield dilutions are summarized in Table 3-3 and 3-4 which also contain the pertinent calculations and comparisons for both methods.

The nearfield dilution achieved will be affected because of the interference between the two jets when they merge. This will result in a smaller "entrainment area" (the surface area of the plume) exposed to "clean" (ambient as opposed to the water in the second plume) water. In addition the plumes will intercept the surface and this will also reduce the entrainment area. When these results are considered, and the geometry of a round jet is maintained, the surface area available for entrainment is reduced to about 50 percent of the area of an otherwise undisturbed double plume, or approximately the same as an undisturbed single plume, past a point about 300 feet from the point of discharge. Table 3.5 shows the nearfield dilution as a function of distance, taking into account the affect of the adjacent propeller slip stream. The calculation scheme and results for determining the factor by which the surface area of the jet is affected are provided in Appendix 9. It is noted that the distance along the nearfield plume is considered at a constant depth below the water and the plume is considered neutrally buoyant with insignificant settling or deepening of the plume (in terms of the farfield model geometry, $x \approx x'$).

The interference of side-by-side plumes and the surface will also act to change the shape of the plume, and result in increased surface area compared to the calculations above. Other factors such as concentration gradients across the plume and the actual flow field also act to make the use of an entrainment area approach somewhat conservative, since actual entrainment areas are expected to be larger than the development presented here. However, to maintain a good degree of conservatism, we have assumed the dilution for both slipstreams combined, once the plumes merge, will be reduced by the entrainment ratio as calculated.

Transition Region

The modeling performed for this study has not strictly attempted to provide a smooth match or connection between the nearfield and farfield plumes. The transition region is ignored. The parameter H, as used in the FEIS farfield model, is the dimension applicable at the beginning of the farfield calculations - but may not match the dimension at the end of the nearfield calculations, arbitrarily taken to be 1000 feet from the vessel. In general, the connection between farfield and nearfield models are seldom rigorous. For the present study, the farfield model is used as an estimate of the additional dilution one might expect in the dumping zone following nearfield dilution. This approach is taken since, from a regulatory perspective, the combination of dumping and nearfield dilution is sufficient and any subsequent farfield dilution is considered a safety factor. The consequences of this approach are discussed in more detail below.

There are three regions (Figure 3.1) to consider following the initial mixing that is referred to as dumping dilution: a region where turbulent diffusion dominates, a transition region where turbulent diffusion and passive diffusion are comparable, and a region where only passive diffusion is acting. The diffusion, and thus dilution, is greater in the turbulent region than in the passive region, and would be intermediate between these two in the transition region. This study takes an approach that considers the nearfield within a region that is dominated by turbulent diffusion in the jet. This region was "arbitrarily" taken as 1000 feet based on examination of the lapse rate of dilution (with distance) compared to the lapse rate of dilution as predicted by the farfield model.

Considered more rigorously, nearfield dilution can be considered to end where passive diffusion is comparable to turbulent diffusion within the plume. This may not be at 1000 feet as assumed and a more justifiable distance, based on specific conditions for each case considered, could be developed. At this point the region where turbulent and passive diffusion would be comparable is ignored and the farfield dilution calculations are applied. Since the transition region would exhibit greater diffusion than the farfield (passive) region, this approach should understate the dilution achieved. This is consistent with the objectives of the study which are not necessarily to provide the most accurate or sophisticated prediction of dilution but rather to provide a prediction to evaluate the impacts of discharge at the edge of the permitted zone in the context of measured toxicity of the waste. If a demonstrably conservative approach shows no impact there is no rationale for refining the predictions.

A smooth transition between the end of the nearfield to the beginning of the farfield would require yet another model that handles both turbulent (turbulence originating from the propeller slip stream) and passive (ambient levels of turbulence) diffusion in the transition region where they are of comparable magnitude. This was not done and the dimensions of the plume between the nearfield and farfield are not necessarily matched. However, the dimension at the beginning of the farfield is the same as previously used in the FEIS and is based on the turning radius of the ship. The reason for this is, that based on the ambient current speed, vessel speed, and dumping track of the vessel, the vessel operations are constrained by the permit such that plume overlap is not, in general, expected except as follows: an overlap type of phenomena is anticipated at the point of plume formation by merging as the vessel turns down current at the end of alternate legs. To account for this eventuality we used a length parameter based on the turning radius of the ship as the worst case starting condition for the farfield calculations just as was done in the FEIS model.

As mentioned above, the value at 1000 feet is taken as the value for the nearfield dilution in the calculations of total dilution described below. Additional justification for this, supporting the discussion above, can be found in Tables 3.3 and 3.4, where the plume velocity at 1000 feet is shown to be comparable to the maximum ambient ocean currents. Thus, nearfield dilution ends when the plume speed approaches the speed of the ambient currents. This is a conservative (under predicts dilution) approach since there will be additional or enhanced dilution in the propeller stream further than this distance for lower than maximum ambient currents

Farfield Dilution

The evaluation of the previous (FEIS) farfield modeling can be summarized fairly succinctly: after examination of the previous work, and considering the characteristics of the new disposal vessel (counter-rotating twin screw propulsion with waste introduced between the screws), the most significant shortcoming of the previous model appears that it very likely substantially underpredicted the initial dilution. To address the implications of the evaluation in more detail an approach was developed to predict the initial and subsequent phases of dilution (dumping dilution and nearfield dilution as described above) that is considered somewhat less conservative in terms of possibly under predicting initial dilution, than the original model. It was not attempted to describe the fate of the waste in great detail or in a rigorously definitive fashion, but to provide estimates sufficient for planning and regulatory decision making and attempting to keep assumptions "conservative" as defined above.

As mentioned above, CH2M HILL used the previously applied farfield transport model implemented on an Excel spreadsheet. The FEIS model is described in Appendix 8 which reproduces Appendix B of the FEIS referenced above. Appendix 8 should be consulted for a thorough review of the physical and mathematical basis of the model, since that description is not reproduced here. As discussed above, when using the same input data as used in the FEIS modeling, the results are in excellent agreement. The geometry and dimensions of the current vessel are used. Initial concentration is set to unity to calculate relative dilutions (or concentrations).

Two key parameters used in this model are the vertical diffusion coefficient, K_V, and the horizontal dissipation parameter, A. Varying these parameters in the model, using the spreadsheet formulation, demonstrated that the results are not particularly sensitive to K_V and are, as expected, moderately sensitive to variations in A. Since the time of development of the FEIS model there is no data that would indicate that these constants should be changed from the previous values, and the same values were used. In addition, a literature survey of recommended values for A indicate that the value used is reasonable for open ocean applications. Fischer (1979) recommends using a value between 0.0002 and 0.001; Yearsley (1989) recommends the same range; Grace (1978) recommends 0.00015 to 0.005; and Baumgartner et al.(1993) recommend 0.0002 to 0.001. These suggested ranges are generally for application to nearshore coastal and inland waters. For open ocean water, with no effects of boundaries and significant wind and wave action, the high end of the suggested range is appropriate. Thus, the value previously used in the FEIS model (0.001) has been retained. Note that units of A as discussed above are $ft^{2/3}/sec$.

As in the case of the previous modeling, the farfield dilution is seasonally dependent based on the strength and structure of the thermocline. Farfield predictions were done for the same set of conditions as done previously:

- A range of ambient ocean current speeds of 0.2 to 1.0 knots

- A range of vessel speeds of 6 and 10 knots
- Winter conditions with no change in K_V with depth
- Summer conditions with K_V dependent on depth (however, only the surface layer was modeled for this case because that is a worst case condition)

The results of the farfield modeling are summarized in Table 3.6 and detailed model output is provided in Appendix 10. Table 3.6 reports the farfield dilution at distances of 2.5 and 5 nautical miles from the release area corresponding to the approximate down current edge of permitted dump zone and the closest point to possible land influence. (These distances are somewhat less than actual distances to the points referenced.) Results for ocean currents of 0.4 knots and 0.8 knots, corresponding to minimum and maximum expected ocean currents (as discussed in the FEIS) are described for vessel speeds of 6 and 10 knots in Table 3.6. Results for additional cases are provided in Appendix 10.

The permits specify in some detail where the disposal is to be done within the designated dump site (Special Condition 4.3.1 through 4.3.3) and a computerized navigational system is required (Special Condition 4.5). The permits further require the master of the vessel to submit a plot of the vessel course for each dumping operation (Special Condition 4.3.4) and maintain and submit a detailed log of operations (Special Condition 4.3.7). Of particular note are the requirements for the vessel positioning for disposal operations which are summarized as follows:

- the vessel "...shall proceed directly to the center of the disposal site"..;
- "...the master of the vessel shall observe the conditions at the dump site center, noting the vessel's position (latitude and longitude), wind direction and observed surface current direction...";
- "...the master of the disposal vessel shall proceed 1.1 nautical miles up current from the center of the disposal site and record the position of the disposal vessel (latitude and longitude). This position shall be the starting point for disposal operations..."

The vessel navigation is done using GPS (and a plot is generated on each trip to the disposal site). Potential errors in navigation are on the order of 100 feet. Therefore, the master of the vessel should have no problem finding the center of the dump zone or positioning the vessel as described above. In addition, using GPS, observing the wind direction, and with a knowledgeable crew familiar with windage and current drift near surface current direction is relatively easy to determine. It is the surface current that is important for the dispersion of the wastes. The wastes are essentially neutrally to slightly positively buoyant (only a very small fraction, if any, will be significantly negatively buoyant) as described by the monitoring data discussed in Section 4 of the report below. Therefore, any deeper currents, that might be in a different direction than the near surface layer, will not be important for dispersion within the dump zone.

The points above provide justification for assuming that the waste will be dumped at the correct location and the nearest distances to the down current edge of the dump site and the nearest shoreline or reef will be greater than 2.5 and 5 nautical miles, respectively. Therefore dilution based on disposal at other than the permit specified locations has not been discussed. However, the information needed to assess the effects of dumping at various distances from the edge of the site is provided in the detailed descriptions of the far-field model results in Appendix 10, and the interested reader may therefore calculate total dilution at any distance from the discharge vessel desired. Figure 3.3 will also provide an estimate of predicted dilutions with distance from the vessel.

Summary of Model Predictions

The dilutions for the range of seasonal and operational parameters are as follows:

- Dumping dilution: The immediate dilution on dumping ranges from approximately 730:1 to 930:1 depending on discharge rate (seasonal constraint) and vessel speed, assuming a maximum permitted discharge per knot of vessel speed.

- Nearfield dilution: The dilution within the propeller slipstream, for first 1000 feet, is predicted to be about 42:1.

- Farfield Dilution: Using essentially the same model as applied in the FEIS the farfield dilution is predicted to range from approximately 11:1 to 30:1 prior to reaching the edge of the dumping zone, and 24:1 to 77:1 prior to reaching the shore line or closest reef area. The farfield dilution depends on a number of environmental and operational variables and can vary from season to season and from day to day.

The dilutions described above are developed in a multiplicative fashion where the dilution is applied to the concentrations at the beginning of the individual mixing processes. Thus the overall dilution at the edge of the dumping zone is the product of the numerical values of the three dilutions described above:

Total dilution = (dumping dilution) x (nearfield dilution) x (farfield dilution)

The results of the model predict minimum dilutions of approximately 400,000:1 at the edge of the dumping zone (for summer conditions with an ocean current of 0.8 knots and a dumping rate of 1200 gallons per minute corresponding to a vessel speed of 10 knots). These dilutions are predicted under what the authors of this report consider to be conservative (under predicted dilutions) and worst case conditions. In addition the farfield dilution calculations are based on centerline or maximum values and the average dilutions within the plume would be less by approximately a factor of two. The range of dilutions, and corresponding concentrations of waste are described in more detail in the concluding section of the report (Section 5). As an example of dilution through the dumping zone from the point of discharge, Figure 3.3 shows dilution as a function of distance for winter and summer conditions that would exhibit the lowest overall dilutions (highest ocean currents and highest permitted dumping rates and vessel speeds).

Deviations from the Study Plan

The original study plan for the modeling is provided in Appendix 2. There were a number of minor deviations from the initially described study plan for the modeling elements of the study. As in any study of this kind, such deviations often arise. All such deviations are, at least implicitly, covered in the report. These deviations included:

- Sensitivity to lateral diffusion and vertical diffusion coefficients: For the reasons presented above, including the difficulty of obtaining site specific field, the same coefficients for horizontal diffusion in the farfield model were applied as used in the FEIS study. Although a formal sensitivity analysis was not done, variations in the coefficient were examined and no reason was found to change the previous value. The examination of monitoring data, presented in Section 4 below, provides a level of confidence that the model predictions are appropriate and the physics of the plume dispersion appear to be somewhat conservatively estimated (dilution appears to be underestimated) by the model and the coefficients used in the model.

- Effluent characteristics of density and settling speed were not explicitly utilized in the modeling (except in reproducing the previous FEIS results). As described in the report we considered the entire plume as a surface plume which provides a worst case analysis and is consistent with the density of the wastes as described in Section 4 below. The initial dilution is so rapid and at such a level that the assumption of neutral buoyancy is very well approximated.

- The field data to rigorously calibrate and verify the model is not available and would be difficult to obtain. Based on the final conclusions concerning toxicity, such an effort is not justified. The available monitoring data, however, was compiled, collated, examined, and evaluated and additionally analyzed to provide a qualitative and potentially semi-quantitative method of evaluating the model predictions. Section 4 below describes this process and the results indicate that this process is sufficient for the purposes of the study.

In general, the study plan was followed, with the minor deviations described above not affecting the usefulness or the application of the study results.

Table 3.1
Comparison of Original FEIS and CH2M HILL Reformulated Model Predicitions

Distance (n. mi.)	Winter Conditions			Summer Conditions		
	CH2MHILL Model	FEIS Model	Percent error	CH2M HILL Model	FEIS Model	Percent error
Cmax/Co for Current Speed of 0.2 knots and Discharge of 500gpm						
0.0	1.00000			1.00000		
0.5	0.06745			0.10016		
1.0	0.03365	0.03364	-0.03	0.05001	0.04999	-0.04
1.5	0.02044	0.02043	-0.04	0.03039	0.03038	-0.05
2.0	0.01380	0.01379	-0.07	0.02053	0.02052	-0.05
2.5	0.00997	0.00996	-0.07	0.01483	0.01482	-0.07
3.0	0.00754	0.00754	-0.06	0.01123	0.01122	-0.07
3.5	0.00591	0.00591	-0.06	0.00880	0.00880	-0.02
4.0	0.00476	0.00476	-0.04	0.00709	0.00709	0.03
Cmax/Co for Current Speed of 0.2 knots and Discharge of 1400gpm						
0.0	1.00000			1.00000		
0.5	0.06745			0.10016		
1.0	0.03365	0.03364	-0.03	0.05001	0.05000	-0.02
1.5	0.02044	0.02043	-0.04	0.03039	0.03039	-0.01
2.0	0.01380	0.01380	0.00	0.02053	0.02052	-0.05
2.5	0.00997	0.00996	-0.07	0.01483	0.01483	-0.01
3.0	0.00754	0.00754	-0.06	0.01123	0.01123	0.02
3.5	0.00591	0.00591	-0.06	0.00880	0.00880	-0.02
4.0	0.00476	0.00476	-0.04	0.00709	0.00709	0.03
Cmax/Co for Current Speed of 0.4 knots and Discharge of 500gpm						
0.0	1.00000			1.00000		
0.5	0.05648			0.08393		
1.0	0.03386	0.03385	-0.02	0.05037	0.05035	-0.04
1.5	0.02305	0.02305	-0.02	0.03431	0.03430	-0.03
2.0	0.01685	0.01684	-0.04	0.02508	0.02507	-0.03
2.5	0.01291	0.01290	-0.04	0.01921	0.01920	-0.06
3.0	0.01023	0.01022	-0.08	0.01523	0.01522	-0.04
3.5	0.00832	0.00831	-0.10	0.01238	0.01238	-0.03
4.0	0.00690	0.00690	-0.06	0.01028	0.01028	0.00
Cmax/Co for Current Speed of 0.4 knots and Discharge of 1400gpm						
0.0	1.00000			1.00000		
0.5	0.05648			0.08393		
1.0	0.03386	0.03385	-0.02	0.05037	0.05036	-0.02
1.5	0.02305	0.02305	-0.02	0.03431	0.03430	-0.03
2.0	0.01685	0.01684	-0.04	0.02508	0.02507	-0.03
2.5	0.01291	0.01290	-0.04	0.01921	0.01921	-0.01
3.0	0.01023	0.01022	-0.08	0.01523	0.01522	-0.04
3.5	0.00832	0.00832	0.02	0.01238	0.01238	-0.03
4.0	0.00690	0.00690	-0.06	0.01028	0.01028	0.00
Cmax/Co for Current Speed of 0.8 knots and Discharge of 500gpm						
0.0	1.00000			1.00000		
0.5	0.04161			0.06190		
1.0	0.02828	0.02827	-0.02	0.04209	0.04207	-0.04
1.5	0.02139	0.02138	-0.04	0.03184	0.03183	-0.04
2.0	0.01694	0.01693	-0.06	0.02522	0.02521	-0.05
2.5	0.01382	0.01382	-0.02	0.02058	0.02058	-0.01
3.0	0.01153	0.01153	-0.02	0.01717	0.01717	-0.01
3.5	0.00979	0.00979	0.01	0.01458	0.01457	-0.04
4.0	0.00843	0.00842	-0.08	0.01255	0.01254	-0.06
Cmax/Co for Current Speed of 0.8 knots and Discharge of 1400gpm						
0.0	1.00000			1.00000		
0.5	0.04161			0.06190		
1.0	0.02828	0.02827	-0.02	0.04209	0.04209	0.01
1.5	0.02139	0.02138	-0.04	0.03184	0.03184	-0.01
2.0	0.01694	0.01694	0.00	0.02522	0.02522	-0.01
2.5	0.01382	0.01382	-0.02	0.02058	0.02058	-0.01
3.0	0.01153	0.01153	-0.02	0.01717	0.01717	-0.01
3.5	0.00979	0.00979	0.01	0.01458	0.01457	-0.04
4.0	0.00843	0.00842	-0.08	0.01255	0.01254	-0.06

Table 3.2
Comparison of Original FEIS and CH2M HILL Reformulated Model Predicitions

Distance (n. mi.)	Summer Deep: CH2MHILL Model	Summer Deep: FEIS Model	Summer Deep: Percent error	Summer Mid-Depth: CH2M HILL Model	Summer Mid-Depth: FEIS Model	Summer Mid-Depth: Percent error
Cmax/Co for Current Speed of 0.2 knots and Discharge of 500gpm						
0.0	1.00000			1.00000		
0.5	0.10348			0.10016		
1.0	0.05168	0.05423	4.70	0.05001	0.04999	-0.04
1.5	0.03141	0.03242	3.11	0.03039	0.03038	-0.05
2.0	0.02122	0.02172	2.31	0.02053	0.02052	-0.05
2.5	0.01533	0.01562	1.87	0.01483	0.01482	-0.07
3.0	0.01161	0.01179	1.57	0.01123	0.01133	0.90
3.5	0.00910	0.00922	1.33	0.00880	0.00947	7.06
4.0	0.00733	0.00741	1.13	0.00709	0.00805	11.95
Cmax/Co for Current Speed of 0.2 knots and Discharge of 1400gpm						
0.0	1.00000			1.00000		
0.5	0.10348			0.10016		
1.0	0.05168	0.05423	4.70	0.05001	0.05000	-0.02
1.5	0.03141	0.03242	3.11	0.03039	0.03039	-0.01
2.0	0.02122	0.02172	2.31	0.02053	0.02052	-0.05
2.5	0.01533	0.01562	1.87	0.01483	0.01483	-0.01
3.0	0.01161	0.01179	1.57	0.01123	0.01133	0.90
3.5	0.00910	0.00922	1.33	0.00880	0.00947	7.06
4.0	0.00733	0.00741	1.13	0.00709	0.00805	11.95
Cmax/Co for Current Speed of 0.4 knots and Discharge of 500gpm						
0.0	1.00000			1.00000		
0.5	0.08674			0.08393		
1.0	0.05206	0.05794	10.15	0.05037	0.05035	-0.04
1.5	0.03546	0.03798	6.63	0.03431	0.03430	-0.03
2.0	0.02592	0.02726	4.92	0.02508	0.02507	-0.03
2.5	0.01986	0.02067	3.93	0.01921	0.01920	-0.06
3.0	0.01574	0.01627	3.27	0.01523	0.01522	-0.04
3.5	0.01280	0.01317	2.80	0.01238	0.01238	-0.03
4.0	0.01063	0.01089	2.43	0.01028	0.01028	0.00
Cmax/Co for Current Speed of 0.4 knots and Discharge of 1400gpm						
0.0	1.00000			1.00000		
0.5	0.08674			0.08393		
1.0	0.05206	0.05795	10.16	0.05037	0.05036	-0.02
1.5	0.03546	0.03799	6.66	0.03431	0.03430	-0.03
2.0	0.02592	0.02727	4.95	0.02508	0.02507	-0.03
2.5	0.01986	0.02067	3.93	0.01921	0.01921	-0.01
3.0	0.01574	0.01627	3.27	0.01523	0.01522	-0.04
3.5	0.01280	0.01317	2.80	0.01238	0.01238	-0.03
4.0	0.01063	0.01089	2.43	0.01028	0.01028	0.00
Cmax/Co for Current Speed of 0.8 knots and Discharge of 500gpm						
0.0	1.00000			1.00000		
0.5	0.06398			0.06190		
1.0	0.04350	0.04207	-3.40	0.04209	0.04207	-0.04
1.5	0.03291	0.03532	6.81	0.03184	0.03183	-0.04
2.0	0.02607	0.02859	8.81	0.02522	0.02521	-0.05
2.5	0.02127	0.02287	6.98	0.02058	0.02058	-0.01
3.0	0.01775	0.01883	5.74	0.01717	0.01717	-0.01
3.5	0.01507	0.01585	4.94	0.01458	0.01457	-0.04
4.0	0.01297	0.01355	4.28	0.01255	0.01254	-0.06
Cmax/Co for Current Speed of 0.8 knots and Discharge of 1400gpm						
0.0	1.00000			1.00000		
0.5	0.06398			0.06190		
1.0	0.04350	0.04208	-3.38	0.04209	0.04208	-0.02
1.5	0.03291	0.03533	6.84	0.03184	0.03184	-0.01
2.0	0.02607	0.02859	8.81	0.02522	0.02522	-0.01
2.5	0.02127	0.02287	6.98	0.02058	0.02058	-0.01
3.0	0.01775	0.01884	5.79	0.01717	0.01717	-0.01
3.5	0.01507	0.01585	4.94	0.01458	0.01457	-0.04
4.0	0.01297	0.01355	4.28	0.01255	0.01254	-0.06

Table 3.3
Dumping Dilution and Nearfield Dilution Calculations for a Single Propeller
Vessel Speed of 6 knots

Round Momentum Jet Theory
(from Sobey, 1994)

Ko	24707	
I1	0.72	
I2	0.36	
alpha	0.096	
Effluent Discharge (waste flow)	1.872	(ft^3/sec)
Dumping Dilution	**366.70**	
Initial Velocity with respect to current	26.27	(knots)
	13.52	(m/s)
	44.34	(ft/sec)
Initial flow through Propeller	557.21	(ft^3/sec)
	15.78	(m^3/s)

Distance from propeller
(25 feet is start of established flow)

Centerline Plume Velocity with respect to current (ft/sec)	feet	Centerline Plume Velocity with respect to ship (ft/sec)
43.55	25	53.74
10.89	100	13.43
5.44	200	6.72
3.63	300	4.48
2.72	400	3.36
2.18	500	2.69
1.81	600	2.24
1.56	700	1.92
1.36	800	1.68
1.21	900	1.49
1.09	1000	1.34
0.54	2000	0.67
0.22	5000	0.27
0.11	10000	0.13

Nearfield Dilution
Momentum jet entrains fluid

Distance (feet)	Flow (ft^3/sec)	Dilution
25	1135	2.04
100	4539	8.15
200	9078	16.29
300	13617	24.44
400	18156	32.58
500	22695	40.73
600	27234	48.88
700	31773	57.02
800	36312	65.17
900	40850	73.31
1000	45389	81.46
2000	90779	162.92
5000	226947	407.29
10000	453894	814.59

Propeller Momentum Theory
(from Liou and Herbich, 1976)

Ships Speed	6	(knots)
Diameter of Propeller	4	(feet)
RPM of propeller	500	
Speed Coefficient (Jt)	0.30	
Thrust Coeficient (Kt)	0.36	
Thrust (T)	12571.99	
Thrust Loading Coefficient (Ct)	27.93	
Ideal Efficiency (n1)	0.31	
coefficient a	2.19	
ceofficient b	4.38	
Current Speed	0	(knots)
	0.00	(ft/sec)
Initial Velocity (Vo) with respect to ship	32.27	(knots)
	16.60	(m/s)
	54.47	(ft/sec)
Initial flow through Propeller (Qo) (for dumping dilution)	684.46	(ft^3/sec)
	19.38	(m^3/s)

Table 3.4
Dumping Dilution and Nearfield Dilution Calculations for a Single Propeller
Vessel Speed of 10 knots

Round Momentum Jet Theory
(from Sobey, 1994)

Ko	84800	
I1	0.72	
I2	0.36	
alpha	0.096	
	Effluent Discharge (waste flow)	
	3.119	(ft^3/sec)

Dumping Dilution
399.91

Initial Velocity with respect to current

48.67	(knots)
25.04	(m/s)
82.15	(ft/sec)

Initial flow through Propeller

1032.29	(ft^3/sec)
29.23	(m^3/s)

Distance from propeller
(25 feet is start of established flow)

Centerline Plume Velocity with respect to current (ft/sec)	feet
80.68	25
20.17	100
10.08	200
6.72	300
5.04	400
4.03	500
3.36	600
2.88	700
2.52	800
2.24	900
2.02	1000
1.01	2000
0.40	5000
0.20	10000

Nearfield Dilution
Momentum jet entrains fluid

Distance (feet)	Flow (ft^3/sec)	Dilution
25	2102	2.04
100	8409	8.15
200	16818	16.29
300	25227	24.44
400	33636	32.58
500	42045	40.73
600	50453	48.88
700	58862	57.02
800	67271	65.17
900	75680	73.31
1000	84089	81.46
2000	168178	162.92
5000	420446	407.29
10000	840891	814.59

Propeller Momentum Theory
(from Liou and Herbich, 1976)

Ships Speed	10	(knots)
Diameter of Propeller	4	(feet)
RPM of propeller	900	
Speed Coefficient (Jt)	0.28	
Thrust Coeficient (Kt)	0.36	
Thrust (T)	41791.50	
Thrust Loading Coefficient (Ct)	33.42	
Ideal Efficiency (n1)	0.29	
coefficient a	2.43	
ceofficient b	4.87	
Current Speed	0	(knots)
	0.00	(ft/sec)
Initial Velocity (Vo) with respect to ship	58.67	(knots)
	30.18	(m/s)
	99.02	(ft/sec)
Initial flow through Propeller (Qo)	1244.38	(ft^3/sec)
(for dumping dilution)	35.24	(m^3/s)

Centerline Plume Velocity with respect to ship (ft/sec)
97.69
24.42
12.21
8.14
6.11
4.88
4.07
3.49
3.05
2.71
2.44
1.22
0.49
0.24

Table 3.5
Nearfield Dilution Calculations

Distance (feet)	Dilution	Entrainment Coefficient	Adjusted Dilution
25	2.04	1.00	2.04
100	8.15	0.79	6.44
200	16.29	0.58	9.45
300	24.44	0.55	13.44
400	32.58	0.53	17.27
500	40.73	0.53	21.59
600	48.88	0.52	25.42
700	57.02	0.52	29.65
800	65.17	0.52	33.89
900	73.31	0.51	37.39
1000	81.46	0.51	41.54

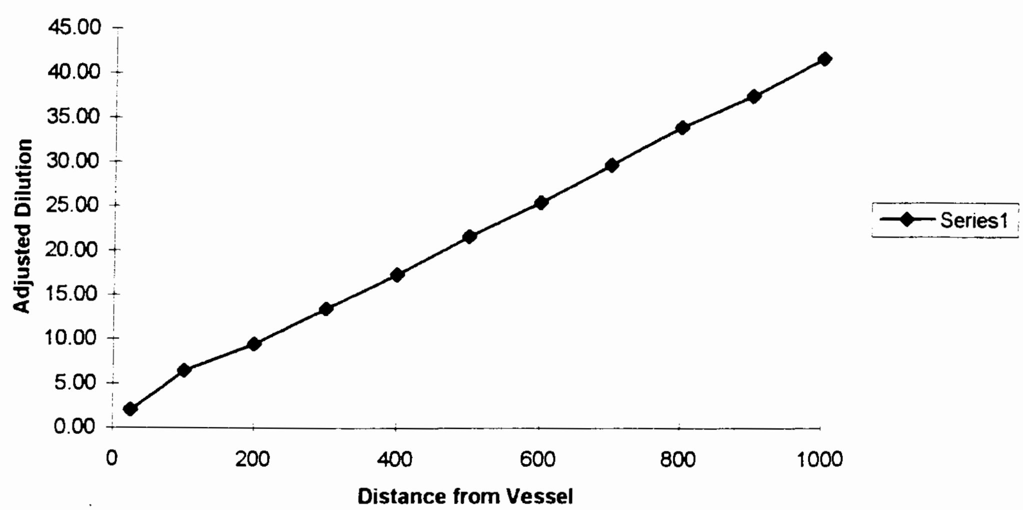
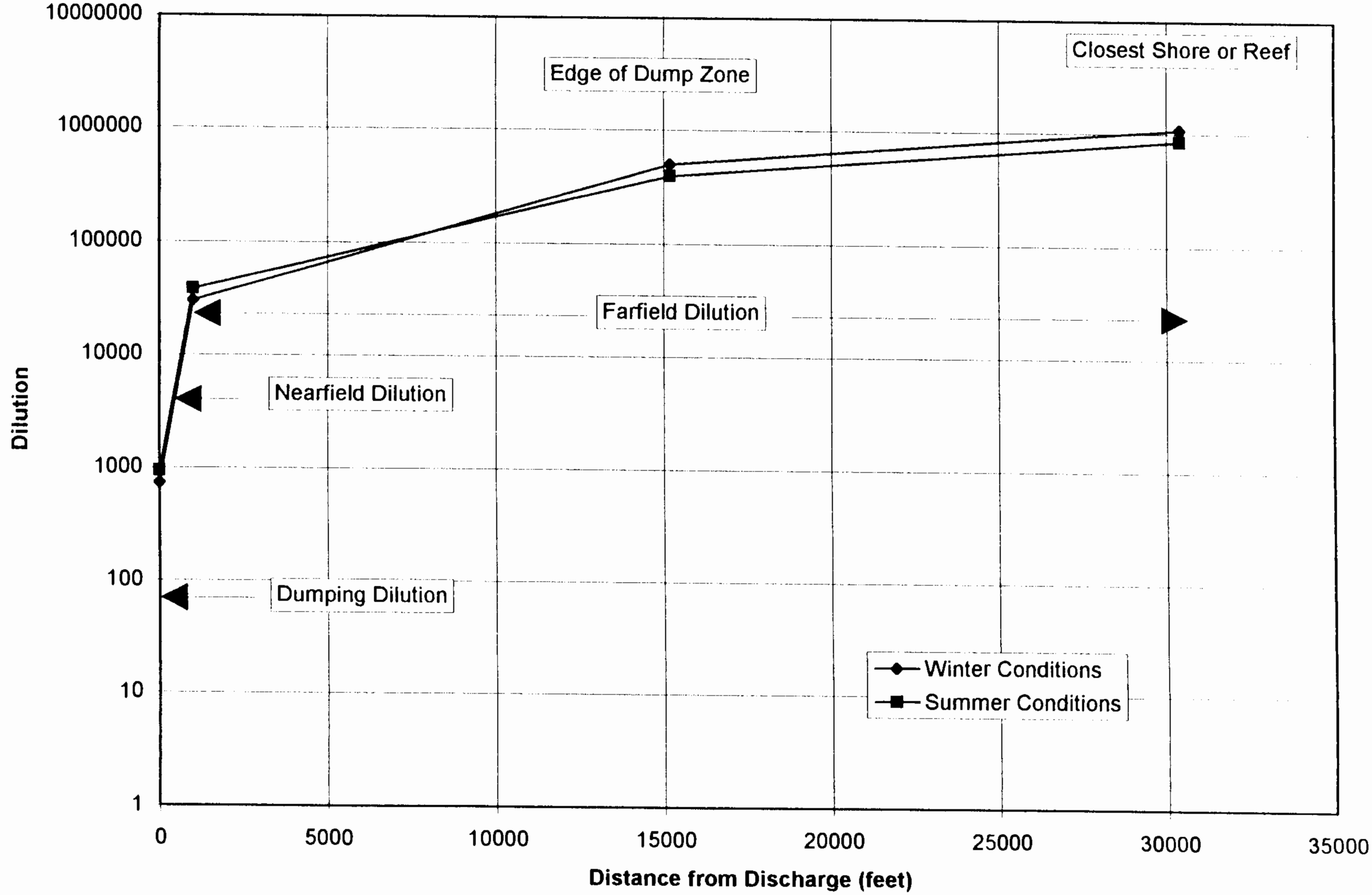


Table 3.6

Farfield Dilution Model Results

Ocean Current (knots)	Vessel Speed (knots)	Dilution	
		Winter Conditions	Summer Conditions
Dilution at 2.5 Nautical Miles Down Current			
0.4	6	29.6	20.0
	10	17.9	12.1
0.8	6	27.6	18.6
	10	16.6	11.2
Dilution at 5 Nautical Miles Down Current			
0.4	6	76.6	51.5
	10	46.1	31.1
0.8	6	59.1	39.7
	10	35.5	23.9

Figure 3.3
Dilution with Distance from Ship



4. Monitoring Data Evaluation

There has been no data collection specifically designed to calibrate or verify model predictions or assess dilution of the wastefield through the approved dumping site. However, the ocean dumping permits do require the canneries to collect waste stream and receiving water data. These data can be used to qualitatively, and to a limited extent, quantitatively, assess the behavior of the wastefield after dumping and assess the general applicability of the model predictions. The available data are first described and examined below (all data discussed in this section of the report is for the time period September 1993 through September 1996). Following the initial description, the data are applied to an evaluation of the wastefield in the receiving water, to the extent possible. The results of the evaluation are also interpreted in terms of the model predictions presented in the previous section. All of the data described in this section of the report is available from EPA Region IX.

Review of Monitoring Data

The canneries are required to collect data from the onshore high strength waste (HSW) storage tanks and monitoring data at the ocean dumping site on a monthly basis. In addition, the canneries must report the daily volumes disposed of at the dump site. Table 4.1 shows the dates of ocean site monitoring and the volumes disposed of by each cannery. The waste from both canneries is maintained separately onshore and combined when pumped into the disposal vessel. Average daily volumes disposed of by each cannery on a monthly basis are listed in Appendix 11. It is noted that on an average basis the volumes are about the same for each cannery with Samoa Packing accounting for approximately 49 percent and StarKist Samoa for about 51 percent.

The onshore data collected by each cannery includes the analysis of certain constituents from the HSW storage tanks. These data were collected twice per month over most of the time period and once per month in the more recent portion of the period. The parameters analyzed include: total suspended solids (as non-filterable reside -TSS), the volatile fraction of the total suspended solids (TVSS), five day biological oxygen demand (BOD_5), oil and grease (O&G), total phosphorus (TP as P), total nitrogen (TN as N), ammonia (as N), pH, and density. The results of the analysis for the period considered (September 1993 through September 1996) are summarized in Table 4.2 and a detailed data compilation is provided in Appendix 11 for each cannery.

The receiving water monitoring data are collected monthly before and after dumping operations. Water samples are collected at three depths (1, 3, and 10 meters below the surface) at six stations as follows:

- Station 1C, a control station at the location where dumping will commence (based on current direction) before dumping starts
- Station 1, in the center of the active dumping area immediately following the discharge of HSW

- Stations 2, 3, and 4, in the center of the "plume" or wastefield as it moves down current (determined visually) at distances of 0.25, 0.5, and 1.0 nautical miles down current of station 1

- Station 5, at the "leading edge" of the wastefield determined as the point furthest downstream from the dumping area where there is still a visual trace of the plume

The parameters measured in the field include pH, temperature, odor, and visual appearance (as well as location determined using GPS, wind, current, and sea conditions). The samples collected are analyzed for: TSS,TVSS, O&G, TP, TN, and ammonia. As mentioned above the dates of ocean monitoring are shown in Table 4.1. Summaries of the analyses carried out for each constituent at each station and depth are given in Table 4.3. Detailed data compilations are provided in Appendix 11. Figures 4.1 through 4.6 show the median values for each of the constituents listed above for each station and depth. The statistics in Table 4.3 and the graphical descriptions in Figures 4.1 through 4.6 were constructed by eliminating obvious outliers (discussed further below) and using the reporting limits for those samples that were not detected. The values are shown in parentheses (outliers eliminated) or are shaded (not detected) in the tables in Appendix 11.

The onshore monitoring samples and the receiving water monitoring samples may sometimes be of the same material but are not from the same material in general. The canneries may sample onshore on different days and neither may coincide with the day of ocean monitoring, or if on the same day may still not be the same material. However, there is a 37 month series of data considered, and long term effects should be well described. Reviewing the data, the median has been chosen as a good representative value. However, all of the data are provided in Appendix 11 if the reader wishes to select a different approach for analysis. It is noted that the median for both the onshore and receiving water data is generally lower than the mean. Significant characteristics of each constituent measured in the receiving water samples are described below:

- TSS measured at the control station, prior to the start of dumping, and at the monitoring stations are essentially indistinguishable (Figure 4.1). Variability in the natural background appears to mask any effect of the wastefield. Occasional very high values are observed and are probably artifacts of a particular sample (for example the sample serendipitously contains a larger organism or piece of natural organic or inorganic detritus). This constituent is unlikely to provide much information concerning the wastefield transport and dilution, other than to indicate that the waste is immediately highly dispersed and diluted since the median discharge values are on the order of 36000 mg/l (see discussion below and Appendix 11) and values measured in the receiving water (including at the control station) are on the order of 1 mg/l.

- TVSS is the volatile fraction of TSS and the same general comments concerning TSS apply as well to TVSS (Figure 4.2). This constituent is also unlikely to provide much information concerning the wastefield transport and dilution, other than to indicate that the waste is immediately highly dispersed and diluted. Median discharge values are on the order of 23000 mg/l (see discussion below and Appendix 11) and values measured in the receiving water (including background) are on the order of 0.5 mg/l.

- O&G is seldom detected at either the control station or at stations within the plume (Figure 4.3). Except for a few anomalous spikes (see Appendix 11), which are infrequent and likely not indicative of the behavior of the wastefield for reasons similar to those described for TSS above. O&G is nearly always not detected at the control station or in the wastefield. Therefore, this constituent is also unlikely to provide much information concerning the wastefield transport and dilution, other than to indicate that the waste is immediately highly dispersed and diluted. Median discharge values are on the order of 22000 mg/l (see discussion below and Appendix 11) and reporting limits in the receiving water samples, including background, are 1 to 0.6 mg/l.

- TP median values are shown in Figure 4.4 for the control station and the stations in the wastefield plume. This constituent illustrates what appears to be a discernible trend or difference between the control station and the wastefield stations. However, the variation is slight and this constituent is not likely to provide comprehensive information concerning the wastefield transport and dilution. TP is probably a better tracer than those constituents discussed above, particularly at the 3 and 10 meter depths. Median discharge values are on the order of 1000 mg/l (see discussion below and Appendix 11) and values measured in the receiving water (including background) are on the order of 0.03mg/l.

- TN median values, shown in Figure 4.5, for the control station and the stations in the wastefield plume illustrate a distinct trend or difference between the control station and the wastefield stations. It must be kept in mind that TN is not a conservative substance, but over the times scales considered (a few hours) TN is probably a better tracer than any of those constituents discussed above. Median discharge values are on the order of 6000 mg/l (see discussion below and Appendix 11) and values measured in the receiving water (including background) are on the order of 0.2 mg/l.

- Ammonia median values, shown in Figure 4.6, for the control station and the stations in the wastefield plume also illustrate a distinct trend or difference between the control station and the wastefield stations. Ammonia, possibly even more so than TN, is not a conservative substance, but over the times scales considered (a few hours) is probably a better tracer than any of those constituents discussed above, with the possible exception of TN. Median discharge values are on the order of 3200 mg/l (see discussion below and Appendix 11) and values measured in the receiving water (including background) are on the order of 0.03 mg/l.

Estimates of Dilution

Under the constraints described above, the monitoring data and onshore waste stream data can be used to estimate the dilution of the wastefield. The median values of the concentrations in the HSW and the receiving water were used for this purpose. The dilution was calculated using the following relationship:

$$S = (C_E - C_A)/(C_P - C_A)$$

where

S = dilution, accounting of ambient concentrations in the diluting water

C_E = concentration of a particular constituent in the HSW

C_A = concentration of the constituent in the ambient receiving water (background)

and

C_P = concentration of the constituent measured at a particular station in the plume.

Dilution is dimensionless (as a ratio) and the concentrations must all be expressed in identical units, in this case mg/l.

The dilution calculations, using the above relationship, were carried out for each constituent at each station and depth and the results of the calculations are shown in Appendix 11 and summarized in Table 4.4. The application of this relationship to the data available will not yield meaningful results if the measured ambient concentration (C_A) is equal to or greater than the measured plume concentration (C_P). In such cases the calculated dilution will be infinite or negative, respectively. For conservative substances, such results are physically meaningless, and simply indicate that the measurements are not done at a fine enough resolution to carry out the calculations. In such cases, the dilution is indicated as N/C (can not be calculated) in Appendix 11 and are not included in the summary in Table 4.4.

The values shown in Table 4.4 are averages of all dilutions calculated using all of the constituents, stations, and depths, that yielded a positive dilution. The trend between Stations 1 through 4 is relatively weak, although on average there is increasing dilution with distance from Station 1. On the other hand Station 5 dilutions are an order of magnitude higher than the other stations. Station 5 is on the leading edge (as visually determined) of the wastefield and Stations 1 through 4 are collected (as visually determined) in the center of the wastefield. The recorded latitudes and longitudes of Stations 4 and 5 were used to estimate the distance between Stations 4 and 5. The detailed calculations are given in Appendix 11 and indicate that Station 5 is approximately 0.4 nautical mile down current of Station 4.

Comparison to Model Results

Comparing the field data analyses discussed above and the model results described in Section 3 of the report is useful and provides insight concerning the validity of the model predictions. However, the field data analysis can not be used for rigorous calibration or verification for at least three reasons: [1] the field data collection was not designed to conform to the model strategy since the model tracks the plume from discharge into the far-field during and following discharge and the field data looks at the overall wastefield following discharge of all material, [2] the laboratory analyses were not, and could not be, carried out to a level of resolution adequate to accurately calibrate a model that must predict dilutions on the order of 10^6:1, [3] the natural variability of the background levels of the constituents measured also prevents use of such data in a model predicting very high dilutions.

The comments above notwithstanding, the field data and analysis can provide a check on the reasonableness of the model predictions. The model predicted dilutions with distance from the discharge point following the initial or dumping dilution are shown in Figure 3.2 above. This figure indicates that the after discharge for a distance of up to about one nautical mile (6000 feet) the dilution in the plume will be between approximately 50,000:1 to 100,000:1. The field data, considered in summary form, as describe in Table 4.4 indicates that the dilution within the center of the final wastefield from the point of initial dumping to within 1 mile is approximately 140,000:1 to 340,000:1. When the average of all stations and depths is considered the dilution is 227,000:1. Thus, through the processes of dumping dilution, subsequent mixing in the propeller slipstream, and including the initial stages of farfield dilution, it appears that the overall prediction of the model is indeed quite conservative (by a factor of about 3:1).

Ocean monitoring Station 5 is at the "leading edge" of the overall wastefield. Where this sample is taken is very subjective and it could be actually at the leading edge of the wastefield as it moves through the dump zone or it could be within the wastefield. There is no strictly comparable model prediction for this station. Values calculated from the field data indicate dilutions that range from 360,000:1 to 6,360,000:1 (see Appendix 11) with an average of 2,800,000 (Table 4.4). As described above, this station is about 1.4 nautical miles down current of the initial starting point for disposal operations. For Station 5, the results strongly indicate, with reference to Figure 3.2, that the model is conservative by a factor of greater than 3:1 in the farfield. It is recognized that measurements from Station 5 are not conclusive because of the nature of the sampling, however, the results fully support those conclusions drawn using information from the other stations.

Table 4.1
Dates of Ocean Monitoring and Volumes Disposed
September 1993 - September 1996

DATE	VOLUME DISPOSED		
	Samoa Packing (gallons)	StarKist Samoa (gallons)	COMBINED (gallons)
10-Sep-93	120,750	190,000	310,750
27-Oct-93	85,000	100,000	185,000
17-Nov-93	151,000	150,000	301,000
10-Dec-93	78,000	80,000	158,000
21-Jan-94	109,000	150,000	259,000
9-Feb-94	67,000	80,000	147,000
9-Mar-94	152,000	140,000	292,000
26-Apr-94	159,000	129,000	288,000
23-May-94	77,000	80,000	157,000
15-Jun-94	130,000	135,000	265,000
21-Jul-94	129,000	130,000	259,000
16-Aug-94	28,300	85,000	113,300
20-Sep-94	147,000	135,000	282,000
1-Oct-94	77,000	85,000	162,000
17-Nov-94	133,000	135,000	268,000
14-Dec-94	74,000	75,000	149,000
27-Jan-95	149,000	135,000	284,000
25-Feb-95	72,000	70,000	142,000
3-Mar-95	111,000	130,000	241,000
8-Apr-95	79,000	85,000	164,000
3-May-95	70,000	125,000	195,000
28-Jun-95	79,000	75,000	154,000
7-Jul-95	139,000	105,000	244,000
1-Aug-95	69,000	130,000	199,000
14-Sep-95	68,000	156,875	224,875
19-Oct-95	101,000	106,867	207,867
15-Nov-95	65,000	110,002	175,002
19-Dec-95	142,000	187,500	329,500
15-Jan-96	87,000	67,500	154,500
7-Feb-96	139,000	166,875	305,875
13-Mar-96	141,000	169,375	310,375
23-Apr-96	142,000	119,375	261,375
2-May-96	140,000	138,750	278,750
19-Jun-96	61,600	53,125	114,725
10-Jul-96	92,700	70,625	163,325
7-Aug-96	103,850	76,250	180,100
5-Sep-96	202,200	123,125	325,325
		Maximum	329,500
		Minimum	113,300
		Average	222,990
		Median	224,875
		Standard Deviation	65,736

Table 4.2
Results of Onshore Composite (Storage Tank) Samples
September 1993 - September 1996

	TSS (mg/L)	TVSS (mg/L)	BOD5 (mg/L)	0&G (mg/L)	TP (mg/L)	TN (mg/L)	Ammonia (mg/L)	pH (SU)	Density (g/ml)
Samples from Samoa Packing Onshore Storage Tank									
No. Samples	62	62	62	61	62	62	62	60.00	62.00
Maximum	86300	72800	480000	404200	3500	19040	8400	7.39	1.03
Minimum	5390	897	11300	919	287	1960	560	5.00	0.98
Mean	22217	14125	49279	37836	1200	6539	2609	6.52	1.00
Median	16800	8770	23200	14780	1200	6160	2430	6.67	1.00
St. Dev.	16346	15464	90696	66742	616	2839	1149	0.52	0.01
Samples from StarKist Samoa Onshore Storage Tank									
No. Samples	70	70	69	70	70	70	70	70.00	70.00
Maximum	150000	131000	136750	187779	3830	14300	10800	7.13	1.04
Minimum	20400	2700	37800	3920	87	1190	282	5.40	0.94
Mean	59122	40832	78533	26103	971	5808	3977	6.57	1.00
Median	53900	36850	72289	21780	832	5560	3875	6.60	1.00
St. Dev.	24702	23284	22434	24512	654	2148	1926	0.30	0.02

Table 4.3
Ocean Monitoring Data
September 1993 - September 1996

	STATION AND DEPTH																	
	CONTROL			STATION 1			STATION 2			STATION 3			STATION 4			STATION 5		
	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)
TSS (mg/L)																		
Minmum	0.4	0.6	0.6	0.5	0.6	0.7	0.6	0.5	0.5	0.6	0.4	0.6	0.4	0.4	0.6	0.5	0.6	0.4
Maximum	6.3	18.0	8.7	7.4	14.9	8.7	9.6	9.5	8.1	7.9	8.3	8.3	14.5	7.0	9.4	6.7	9.4	6.8
Mean	1.6	1.8	2.0	1.8	2.1	1.9	1.9	1.9	2.0	1.6	1.4	1.8	2.3	1.9	1.8	1.5	1.5	1.7
Median	1.4	1.0	1.7	1.2	1.6	1.5	1.4	1.5	1.4	1.2	1.0	1.2	1.6	1.5	1.4	1.2	1.1	1.4
Std. Dev.	1.0	2.8	1.5	1.5	2.4	1.6	1.7	1.6	1.8	1.4	1.4	1.4	2.6	1.4	1.6	1.1	1.4	1.2
No. of Samples	37	37	37	37	37	36	37	37	37	36	37	35	37	36	37	37	37	37
TVSS (mg/L)																		
Minmum	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.2	0.1
Maximum	1.4	1.3	2.9	1.3	2.4	1.9	3.5	1.9	1.6	1.3	1.4	1.8	2.7	2.6	1.5	1.4	1.2	2.5
Mean	0.5	0.4	0.7	0.6	0.7	0.7	0.7	0.6	0.6	0.5	0.5	0.6	0.6	0.6	0.5	0.4	0.5	0.6
Median	0.4	0.4	0.6	0.5	0.5	0.6	0.5	0.6	0.6	0.4	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.4
Std. Dev.	0.3	0.2	0.5	0.4	0.5	0.4	0.6	0.4	0.4	0.3	0.3	0.4	0.5	0.5	0.3	0.3	0.2	0.4
No. of Samples	36	35	36	36	36	35	36	36	37	35	36	34	35	35	36	36	36	36
O&G (mg/L)																		
Minmum	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Maximum	1.00	1.00	1.12	1.00	1.60	1.28	1.28	1.00	1.79	1.00	1.00	1.00	1.00	1.00	3.20	1.08	1.00	1.00
Mean	0.64	0.64	0.65	0.65	0.67	0.66	0.66	0.64	0.69	0.64	0.64	0.63	0.64	0.64	0.71	0.66	0.64	0.64
Median	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
Std. Dev.	0.11	0.11	0.13	0.12	0.19	0.15	0.15	0.11	0.25	0.11	0.11	0.09	0.11	0.11	0.43	0.14	0.11	0.11
No. of Samples	37	37	37	37	37	36	37	37	37	37	37	36	34	36	37	37	37	37
OCEAN MONITORING DATA FOR TOTAL PHOSPHOROUS (mg-P/L)																		
Minmum	0.009	0.012	0.008	0.014	0.013	0.009	0.012	0.006	0.005	0.009	0.005	0.012	0.012	0.006	0.006	0.006	0.007	0.006
Maximum	0.520	0.114	0.093	0.239	0.571	0.096	0.125	0.240	0.571	0.078	0.057	0.213	0.390	0.243	0.115	0.239	0.059	0.079
Mean	0.054	0.029	0.032	0.039	0.047	0.037	0.038	0.044	0.050	0.031	0.027	0.034	0.052	0.040	0.034	0.044	0.028	0.028
Median	0.030	0.024	0.026	0.029	0.030	0.033	0.031	0.029	0.034	0.029	0.024	0.028	0.028	0.030	0.029	0.028	0.026	0.024
Std. Dev.	0.090	0.019	0.019	0.040	0.090	0.017	0.027	0.046	0.090	0.016	0.012	0.033	0.078	0.041	0.021	0.048	0.013	0.015
No. of Samples	37	37	37	37	37	37	37	37	37	37	37	37	37	37	36	37	37	37
TOTAL NITROGEN (mg-N/L)																		
Minmum	0.033	0.106	0.090	0.116	0.097	0.094	0.106	0.106	0.076	0.088	0.088	0.115	0.102	0.105	0.098	0.090	0.102	0.102
Maximum	0.568	0.356	0.771	0.785	0.618	0.712	0.590	0.612	0.659	0.492	0.518	0.970	0.860	0.640	0.418	0.945	0.345	0.422
Mean	0.178	0.172	0.229	0.268	0.245	0.269	0.227	0.222	0.237	0.196	0.200	0.245	0.223	0.206	0.193	0.187	0.167	0.176
Median	0.151	0.151	0.187	0.232	0.206	0.239	0.181	0.190	0.187	0.180	0.177	0.183	0.183	0.179	0.174	0.148	0.149	0.150
Std. Dev.	0.091	0.064	0.157	0.154	0.123	0.133	0.115	0.116	0.134	0.087	0.097	0.175	0.140	0.100	0.076	0.150	0.057	0.072
No. of Samples	36	37	37	37	37	37	37	37	37	37	37	37	37	37	36	37	37	37
AMMONIA (mg-N/L)																		
Minmum	0.001	0.003	0.001	0.005	0.004	0.005	0.003	0.003	0.001	0.004	0.005	0.004	0.005	0.003	0.003	0.002	0.003	0.004
Maximum	0.250	0.093	0.199	0.147	0.182	0.164	0.191	0.132	0.127	0.134	0.139	0.140	0.118	0.135	0.202	0.260	0.105	0.197
Mean	0.026	0.015	0.024	0.051	0.053	0.051	0.045	0.043	0.046	0.038	0.039	0.042	0.036	0.038	0.043	0.028	0.019	0.029
Median	0.013	0.012	0.014	0.035	0.038	0.034	0.028	0.033	0.039	0.025	0.037	0.032	0.028	0.026	0.029	0.015	0.012	0.014
Std. Dev.	0.044	0.015	0.036	0.045	0.049	0.042	0.045	0.037	0.037	0.034	0.029	0.035	0.032	0.035	0.051	0.044	0.022	0.039
No. of Samples	37	37	36	36	37	36	36	36	36	37	37	37	37	37	36	36	36	37

Table 4.4
Average Dilutions Calculated from Ocean Monitoring Data

	Depth			
Calculated Dilutions at:	**1 m**	**3 m**	**10 m**	**Average**
Station 1 @ 0.0 nmiles	227,928	138,122	137,233	167,761
Station 2 @ 0.25 nmiles	214,950	139,169	126,650	160,256
Station 3 @ 0.5 nmiles	231,674	176,086	338,072	248,611
Station 4 @ 1.0 nmiles	201,548	171,089	307,717	226,785
Average Stations 1-4	219,025	156,116	227,418	200,853
Station 5 - Leading Edge	1,590,694	432,544	6,362,773	2,795,337

Figure 4.1
Median Values of TSS from Ocean Monitoring

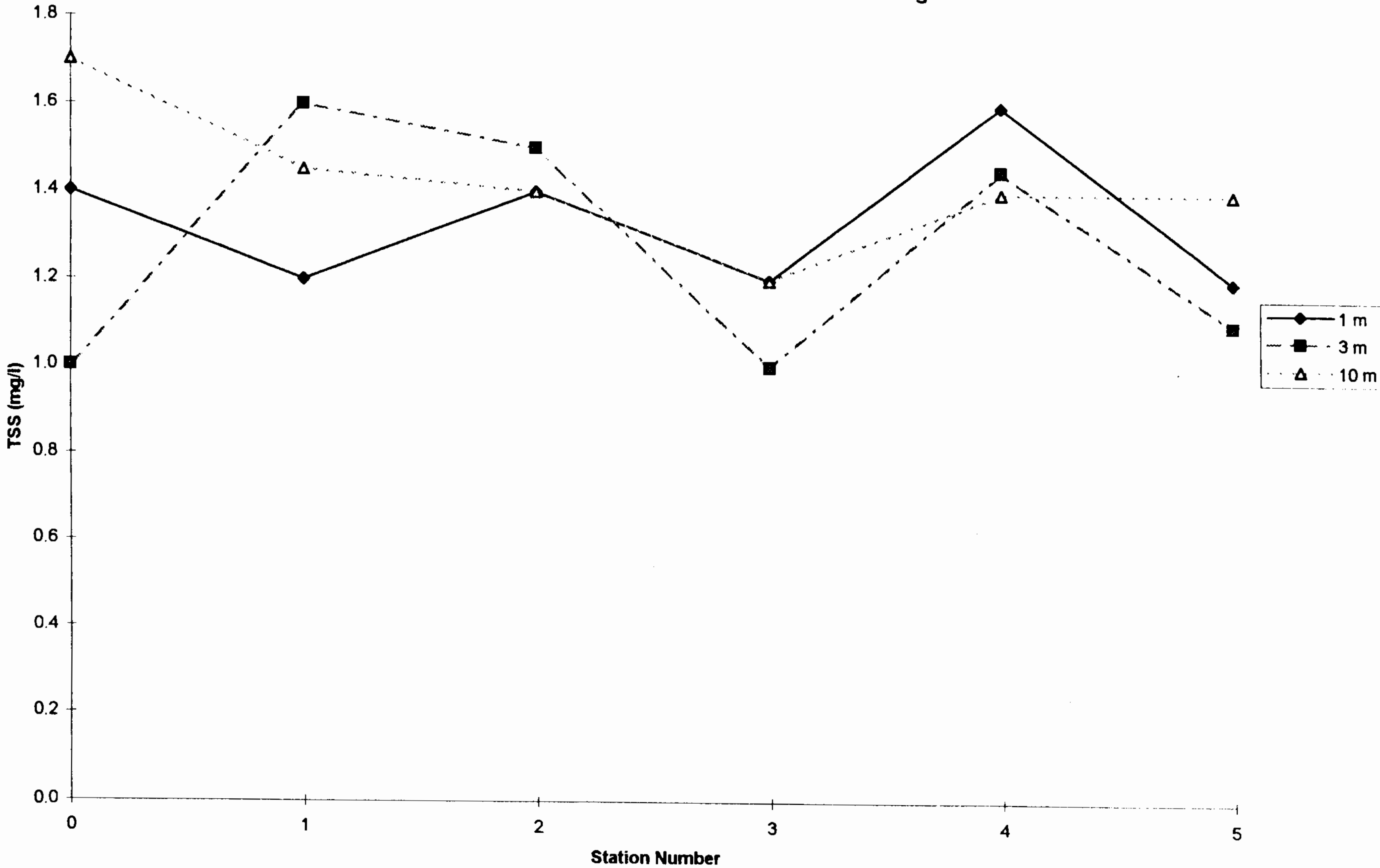


Figure 4.2
Median Values of TVSS from Ocean Monitoring

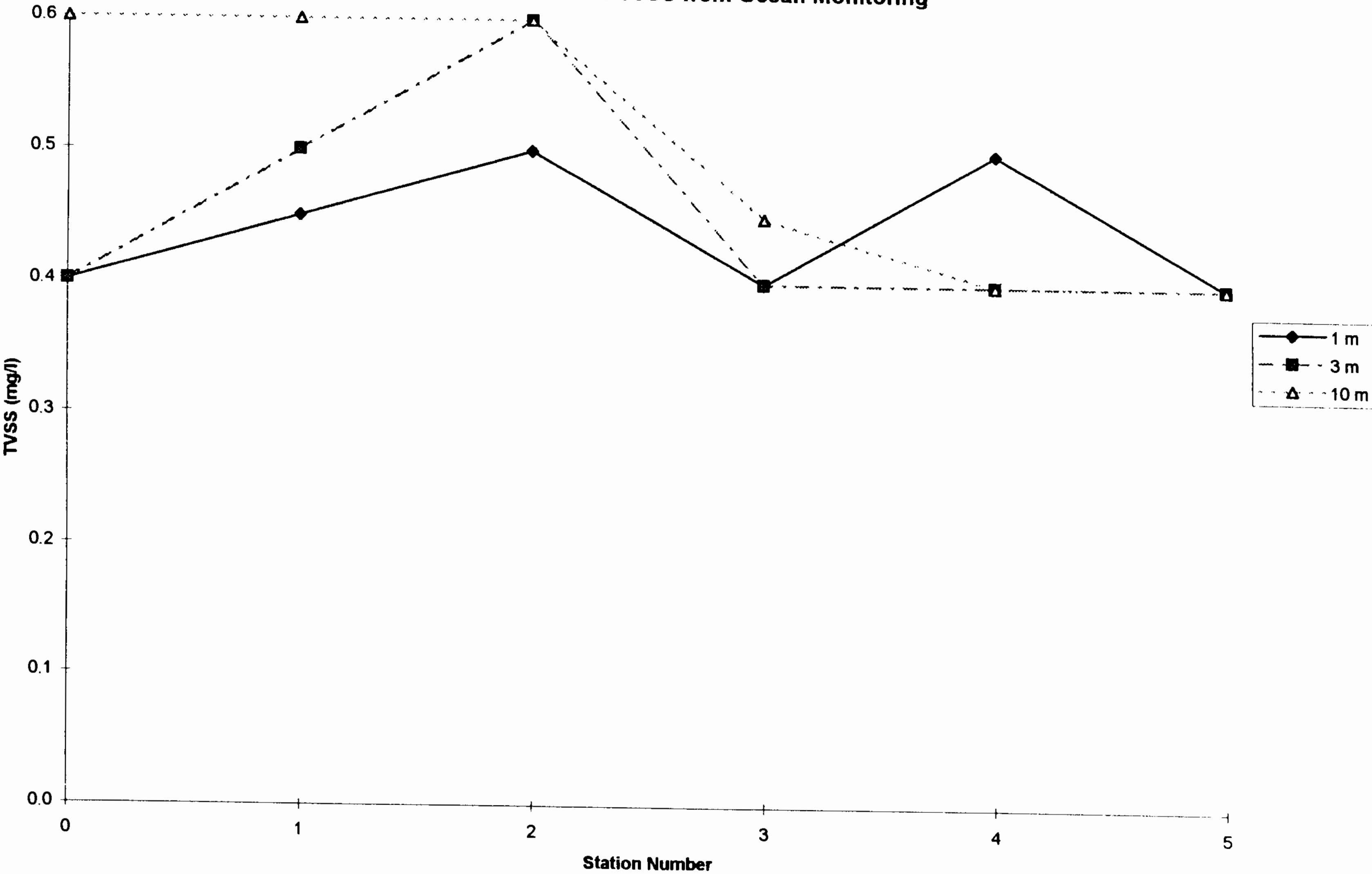


Figure 4.3
Median Values of O&G from Ocean Monitoring

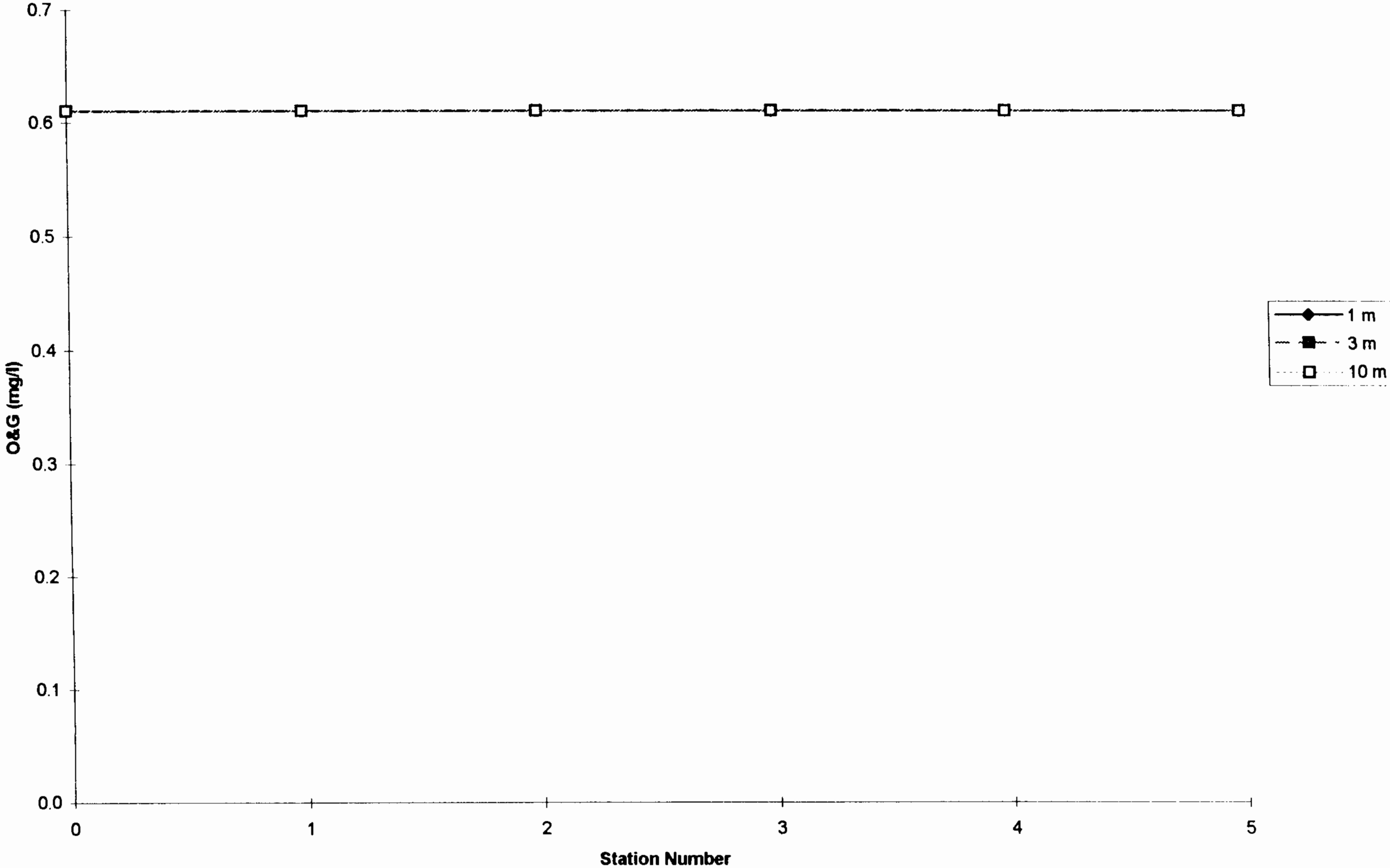


Figure 4.4
Median Values of Total Phosphorus from Ocean Monitoring

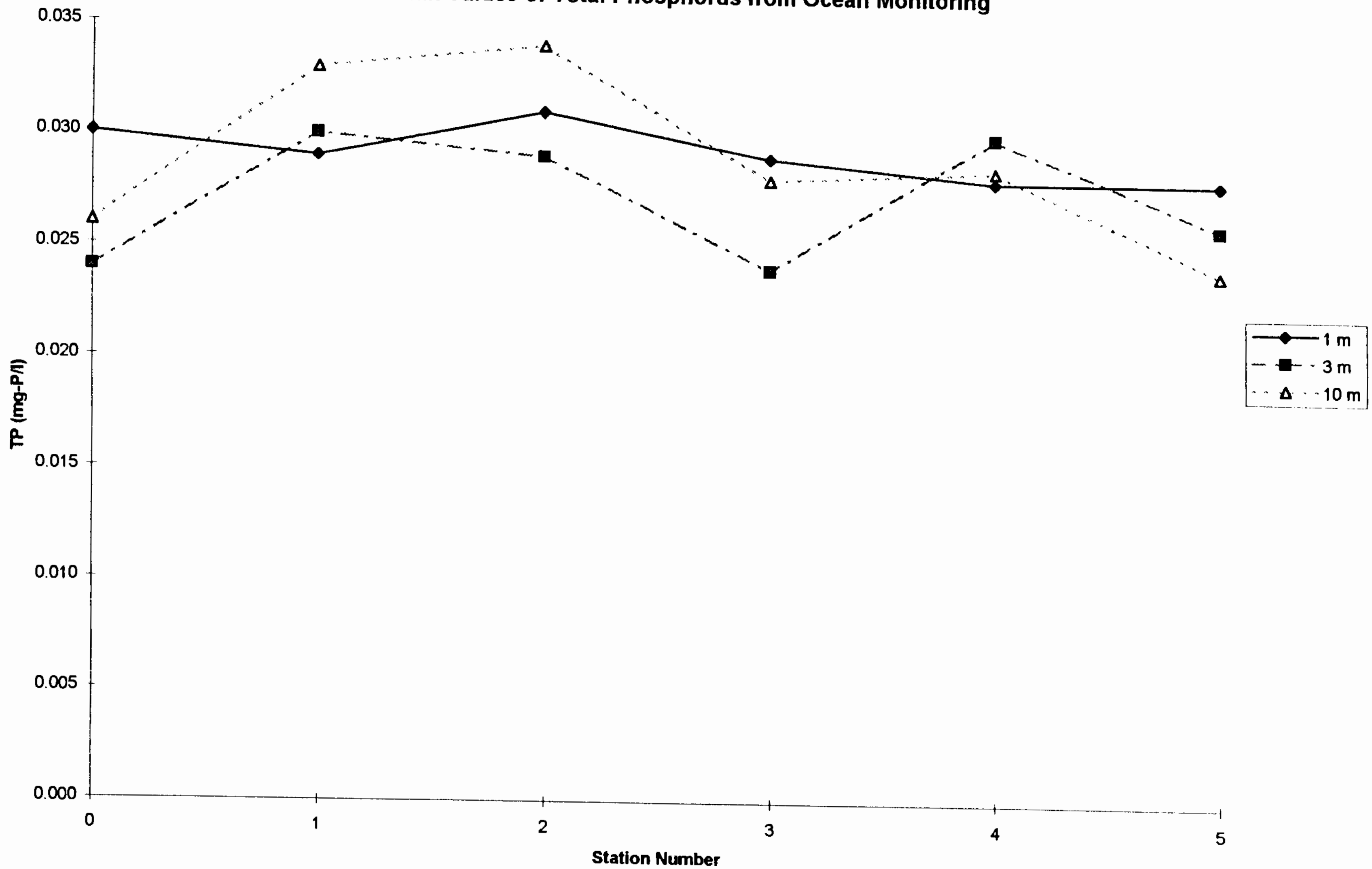


Figure 4.5
Median Values of Total Nitrogen from Ocean Monitoring

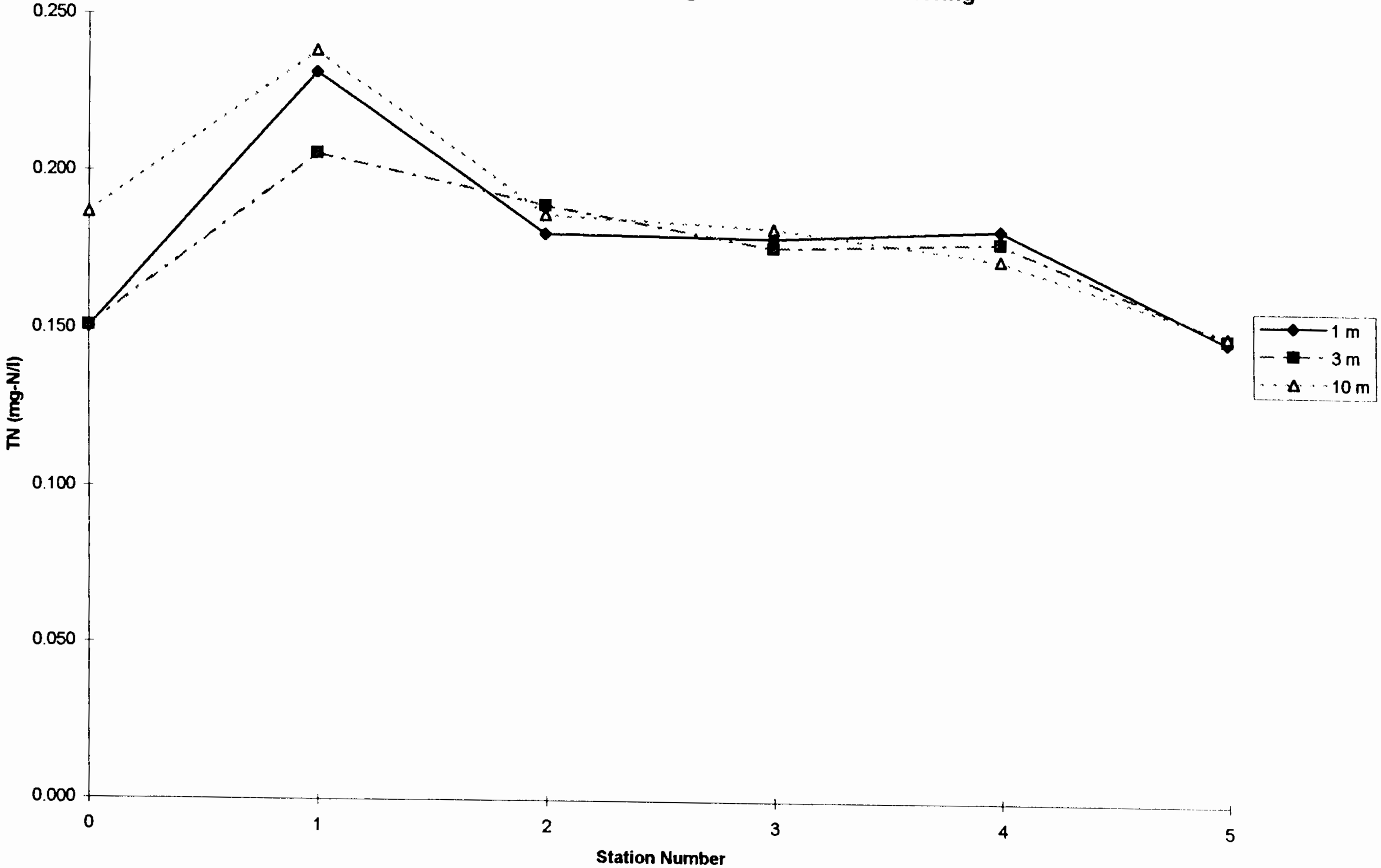
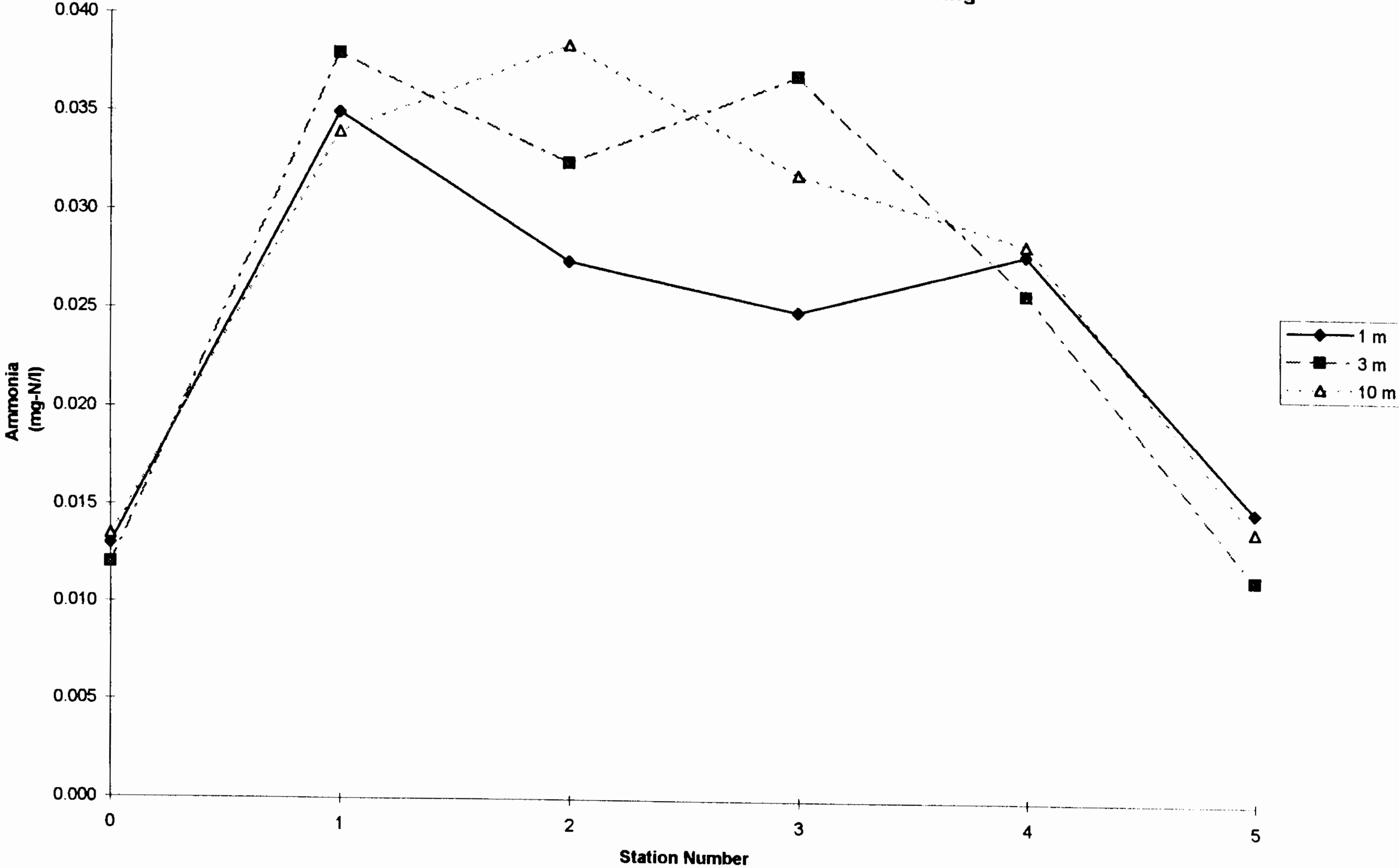


Figure 4.6
Median Values of Ammonia from Ocean Monitoring



5. Conclusions and Recommendations

This section presents the overall conclusions drawn from the model predictions, the model limitations, and recommendations based on the results of the study.

Conclusions

Table 5.1 shows the prediction of total dilution and final concentration prior to the point where the plume reaches the edge of the dumping zone (taken as 2.5 nautical miles down current). In the table, C/C_0 is the ratio of final to initial concentration and can be applied to calculate the concentration of any known constituent in the waste. The final concentration is also given in terms of an approximate value for the whole waste in mg/l, assuming the waste is about the density of water. At the edge of the dump zone the maximum predicted concentration of the waste is diluted to about 0.00025 percent HSW (Table 5.1: summer, ocean current 0.8 knots, vessel speed 10 knots). Reference to Table 3.1 shows that the lowest LC50 of all bioassays conducted was 0.12 percent HSW. Therefore, the concentration at the edge of the permitted dumping zone is 0.0021·LC50.

Table 5.2 shows the same information described above for the plume prior to reaching the shoreline (taken as 5 nautical miles down current). The model was formulated and implemented in a conservative fashion and the dilutions are expected to be underpredicted (concentrations over predicted). Available monitoring data indicates that the dilutions predicted by the model in the farfield (approximately 1.4 nautical miles from the dump zone) are in fact under predicted by a substantial degree.

Limitations

Most numerical models of the type used here contain coefficients (e.g. friction factors, diffusion coefficients) that are often study site specific. Although there are generally accepted values for these coefficients, the range observed in nature is high and the models can be somewhat sensitive to the values selected. The process of calibration and verification generally uses measured values of forcing functions and responses to determine the appropriate coefficients for the model configuration at the study site. Typically a set of field data is used to determine the correct values to use for the coefficients. However, there is little or no available and appropriate data for formal model verification. In this case the model sensitivity determination, the use and justification of reasonable values from the literature and similar studies, and the incorporation of a prudent level of conservatism is required and was accomplished. The available monitoring data were examined and evaluated and confirm the conclusions drawn from the model predictions.

Recommendations

CH2M HILL project staff, on the basis of the results of the study, have no recommendations for additional studies of this type.

Table 5.1
Predicted Dilution and Concentration at the Down Current Edge of the Ocean Dumping Zone (at 2.5 Nautical Miles)

Season	Ocean Current (knots)	Vessel Speed (knots)	Loading (gpm)	Dumping Dilution Sd	Nearfield Dilution Sn	Farfield Dilution Sf	Total Dilution St	Final Concentration 1/(St)	Final Concentration (mg/l)
Winter	0.4	6	840	796.2	41.5	29.6	978,052	0.000001022	1.022
Winter	0.4	10	1400	731.4	41.5	17.9	543,320	0.000001841	1.841
Winter	0.8	6	840	796.2	41.5	27.6	911,967	0.000001097	1.097
Winter	0.8	10	1400	731.4	41.5	16.6	503,861	0.000001985	1.985
Summer	0.4	6	720	931.6	41.5	20.0	773,190	0.000001293	1.293
Summer	0.4	10	1200	855.7	41.5	12.1	429,709	0.000002327	2.327
Summer	0.8	6	720	931.6	41.5	18.6	719,067	0.000001391	1.391
Summer	0.8	10	1200	855.7	41.5	11.2	397,747	0.000002514	2.514

Note: St=Sd*Sn*Sf

Table 5.2
Predicted Dilution and Concentration near the Closest Reefline or Shoreline (at 5 nautical miles)

Season	Ocean Current (knots)	Vessel Speed (knots)	Loading (gpm)	Dumping Dilution Sd	Nearfield Dilution Sn	Farfield Dilution Sf	Total Dilution St	Final Concentration 1/(St)	Final Concentration (mg/l)
Winter	0.4	6	840	796.2	41.5	76.6	2,531,040	0.000000395	0.395
Winter	0.4	10	1400	731.4	41.5	46.1	1,399,278	0.000000715	0.715
Winter	0.8	6	840	796.2	41.5	59.1	1,952,800	0.000000512	0.512
Winter	0.8	10	1400	731.4	41.5	35.5	1,077,535	0.000000928	0.928
Summer	0.4	6	720	931.6	41.5	51.5	1,990,964	0.000000502	0.502
Summer	0.4	10	1200	855.7	41.5	31.1	1,104,458	0.000000905	0.905
Summer	0.8	6	720	931.6	41.5	39.7	1,534,782	0.000000652	0.652
Summer	0.8	10	1200	855.7	41.5	23.9	848,764	0.000001178	1.178

Note: St=Sd*Sn*Sf

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Appendix 1
Special Condition 3.3.5 of Ocean Dumping Permits

3.3.5. Eighteen months from the effective date of this special permit, the permittee shall submit a report to EPA and ASEPA on the results of suspended phase bioassay tests and reevaluation of the model used to predict the concentrations of fish processing wastes disposed at the designated site. The suspended phase bioassays shall be conducted using at least one species from each of the following three groups: Group 1 = *Mytilus* sp. (mussel), *Crassostrea* sp. (oyster), *Acartia tonsa* (copepod), or *Trypneustes* sp. (sea urchin) larvae; Group 2 = *Holmesimysis costata* (mysid shrimp) or *Penaeus vannamei* (white shrimp); and Group 3 = *Citharicthys stigmaeus* (speckled sanddab) or *Coryphaena hippurus* (dolphinfish) juveniles.

Appropriate suspended phase bioassay protocols, either protocols approved by EPA or protocols published by the American Society for Testing and Materials (ASTM), shall be followed. Suspended particulate phase bioassays shall be run using the following fish processing waste concentrations: 100%, 75%, 50%, 25%, 10%, 5%, and a control (0%). A minimum of five replicates are required per dilution concentration. Concurrent reference toxicant tests shall be conducted when the suspended phase bioassays are run.

A sampling and testing plan shall be submitted to EPA Region IX and ASEPA by October 1, 1993 for approval before the bioassay tests are conducted. Samples for the suspended particulate phase bioassays shall be composited from the permittee's onshore storage tanks. Three samples shall be taken from the onshore storage tank transfer line at 10 minute intervals. These samples shall be composited to produce one sample for analysis. The permittee's samples shall not be combined with fish processing waste from any other permittee. The permittee shall take samples on the following dates: November 30, 1993, February 28, 1994 and May 31, 1994. Samples shall be collected and shipped to the testing laboratory according to EPA-approved methods to ensure that the samples do not change before the bioassay tests begin. All suspended particulate phase bioassays shall be started within 10 days of sampling.

The testing plan submitted by October 1, 1993 should also include a proposal to reevaluate the disposal site model using results obtained from the new series of suspended phase bioassays. These bioassays are being required to confirm the toxicity of the fish processing wastes and to reevaluate the disposal operations based on the use of a different disposal vessel.

The bioassay and computer model confirmation report shall contain the following information:

3.3.5.1. INTRODUCTION AND PROJECT DESCRIPTION

The project description should include the following information about fish processing waste toxicity, previous bioassay test results, previous modelling at the ocean disposal site, and the design of the new bioassay tests.

3.3.5.2. MATERIALS AND METHODS

Fish processing waste sampling and sample handling procedures should be described or referenced.

References for laboratory protocols for suspended phase bioassay tests.

1) EPA-approved methods and references.

2) Test species used in each test, the supplier or collection site for each test species, and QA/QC procedures for maintaining the test species.

3) Source of seawater used in reference, control and bioassay tests.

4) Data and statistical analysis procedures.

5) Limiting Permissible Concentration (LPC) calculations.

6) Description of model selected to evaluate dispersal of fish processing wastes at the ocean disposal site. Use of this model shall be approved by EPA Region IX and ASEPA before it is used by the permittee to evaluate the fish processing waste disposal plume.

3.3.5.3. DESCRIPTION OF SAMPLING PROCEDURES

QA/QC procedures and actual sampling procedures used during fish processing waste stream sampling and handling of the samples.

3.3.5.4. FINAL RESULTS, ANALYSIS OF DATA AND DISCUSSION

1) Complete bioassay data tables and summary bioassay tables shall be furnished in the report. All data tables should be typed or produced as a computer printout.

2) The permittee shall analyze the bioassay data and calculate the LPC of the material as defined at 40 C.F.R. § 227.27(a-b).

3) The permittee shall use the LPC in the approved plume model to determine the concentration of fish processing wastes disposed at the designated ocean disposal site which complies with EPA's Ocean Dumping Criteria defined at 40 C.F.R. Parts 227 and 228.

3.3.5.5. REFERENCES

This list should include all references used in the field sampling program, laboratory protocols, LPC calculations, modelling analyses, and historical data used to evaluate the fish processing waste disposal operations at the designated ocean disposal site.

3.3.5.6. DETAILED QA/QC PLANS AND INFORMATION

The following topics should be addressed in the QA Plan:

1) QA objectives.

2) Organization, responsibilities and personnel qualifications, internal quality control checks.

3) Sampling and analytical procedures.

4) Equipment calibration and maintenance.

5) Sample custody and tracking.

6) documentation, data reduction, and reporting.

7) Data validation.

8) Performance and systems audits.

9) Corrective action.

10) Reports.

Appendix 2
Study Plan (Draft and Incorporated EPA Comments)

DRAFT STUDY PLAN

FOR

JOINT CANNERY OCEAN DUMPING STUDIES

IN

AMERICAN SAMOA

Prepared for

StarKist Samoa
(Permit OD 93-01 Special)

and

VCS Samoa Packing
(Permit OD 93-02 Special)

Prepared by

CH2M HILL
11 November 1993

STUDY PLAN
FOR
JOINT CANNERY OCEAN DUMPING STUDIES
IN
AMERICAN SAMOA

Special ocean dumping permits have been issued to StarKist Samoa, Inc. and VCS Samoa Packing, Inc. because the Regional Administrator of EPA Region IX has determined that disposal of fish processing wastes off American Samoa meets EPA's ocean dumping criteria at 40 CFR Parts 227 and 228. Special condition 3.3.5 of both permits requires bioassay testing of the waste from each cannery and a re-evaluation of the model previously used to predict concentrations of fish processing wastes disposed of at the designated site. A copy of this special condition is provided in Appendix 1 of the study plan.

The special permit condition addresses two distinct efforts: bioassay testing and model re-evaluation. Although the results of the bioassay testing will be used in the final steps of the model re-evaluation, the two parts of the study are quite different and are best described independently. Therefore, this study plan is presented in two parts:

- Part I: Plan of Study for Bioassay Toxicity Tests
- Part II: Plan of Study for Modeling Re-evaluation

The two portions of the study will be conducted independently except as noted above. References are provided separately for part of the study plan. Additional information is provided in Appendices.

Part I

PLAN OF STUDY FOR BIOASSAY TOXICITY TESTS

INTRODUCTION

Under special conditions 3.3.5 of the Ocean Disposal Dumping Permits, StarKist Samoa and VCS Samoa Packing are required to conduct and submit the results of toxicity tests on fish processing wastes generated at the permittees' American Samoa packing plants. The toxicity tests are to be initiated within 10 days following sampling on November 30, 1993, February 28, 1994, and May 31, 1994. The wastes to be tested include DAF sludge and other high strength waste streams that are barged to sea for disposal at the permitted dump site. This part of the study plan describes the methods proposed to conduct the bioassay tests. The results of the tests will also be incorporated into the modeling re-evaluation described below in Part II of the study plan.

General guidance for these tests is provided by USEPA (1991), ASTM (1992), and the EPA/COE "Green Book" (1991). Specific guidance for performing biological-effects tests for Ocean Disposal permits are outlined in Part III, Section 11 of the Green Book; *Evaluation of Dredged Material Proposed for Ocean Disposal: Testing Manual* (EPA and COE, 1991). However, the fish processing wastes to be disposed under this permits are not similar to solid dredged materials. The high strength waste materials are mostly liquid phase wastes which are positively to neutrally buoyant with a small fraction of negatively buoyant solid particles. This waste is not expected to behave in a fashion typical of solid, generally negatively buoyant, dredge spoil material when disposed of by dumping at sea. Therefore, the physical and chemical nature of the wastes requires modifications to the suspended bioassay tests as outlined in the Green Book.

The following Methods sections include the specific modifications required to properly evaluate the toxicity of the tuna cannery high strength wastes. A description of the proposed reporting schedule and format for the bioassay test results is provided in the Reports section.

SAMPLING METHODS

Sample Composition

High strength waste samples will be collected at each cannery from the existing sampling ports in the storage tank transfer lines. Three samples will be taken at 10 minute intervals while waste is being transferred from the storage tanks to the barge. Samples for the bioassay tests will be composited from the three discrete samples. Waste from each cannery will be collected and shipped separately and shall not be combined.

Sampling Times

Sampling will be conducted on the following days, if possible:

- Tuesday, November 30, 1993
- Monday, February 28, 1994
- Tuesday, May 31, 1994

If a cannery is shut down, or material is not being transferred to the barge on that day, sampling will be done at the first available time.

Sample Shipping and Handling

EPA approved chain-of custody, sample shipping and handling, and record keeping will be conducted to preserve and monitor the integrity of the samples used for the required bioassays. Samples will be cooled at the canneries after collection and then packed in ice for shipment. The permit requires tests will be initiated within 10 days of sample collection. There are significant and well recognized problems with shipment of material from American Samoa. Every reasonable effort will be made to meed the required 10-day maximum holding time. If the holding times are exceeded for some reason, EPA Region IX will be contacted to determine if the tests should be initiated or if new samples should be collected and shipped.

TEST METHODS

Selected Species

The permit condition requires testing of three species selected from three groups listed in section 3.3.5 of the permit. We propose tests be conducted with the pacific mysid shrimp (*Holmesimysis costata*) juveniles, pacific sanddab (*Citharicthys stigmaeus*) juveniles, and purple sea urchin (*Strongylocentrotus purpuratus*) larvae. These species and life stages were chosen because they represent sensitive crustacean, fish, and zooplankton components of the marine community, tolerate laboratory conditions, and can be readily tested as young life-stages. These species are also routinely used in conducting bioassays for the ocean disposal permit program. Of great importance are the practicality and year-round availability of the appropriate life-stages of all three of the above species.

The shrimp and fish species were selected from the lists (Group 2 and Group 3, respectively) specified in the permit special condition. The sea urchin species (*Strongylocentrotus purpuratus*) was not listed in the permit (Group 1). We have recommended a different species because it is important that the same species and life-stages be used for each test series conducted. Three test series of bioassays will be conducted over approximately 9 months. The rationale for recommending a different species is as follows:

- The mollusc species listed in Group 1 (*Mytilus* sp. and *Crassostrea* sp.) and the copepod (*Acartia tonsa)* are potentially difficult to obtain at the appropriate life stage at all of the times specified in the permit condition.

- Therefore, sea urchin larvae, also listed in Group 1, are proposed for these tests instead of mollusc or copepod because of their availability at all times of the year.

- However, the sea urchin specifically listed (*Trypneustes* sp.) is not readily available and may be difficult to obtain, particularly at the specific times as required in the permit and an alternate sea urchin species (*Strongylocentrotus purpuratus*) is recommended.

With a limited number of opportunities to evaluate the toxicity of the material to be disposed, it is important to compare the results of bioassay tests using the same species and life-stages.

If necessary, *Mytilus* sp. (mussels) will be used as a backup species to the sea urchin and white shrimp (*Paneaus vannamai*) will be used as a back-up test species for the mysid shrimp should the primary test species be unavailable at the time of the bioassays. All reasonable efforts will be made to consistently use the primary test species.

Acclimation and Holding

All test organisms will be brought into the laboratory and gently acclimated to test conditions and control water (dilution water) for a minimum of 24 hours prior to test initiation. Salinity, temperature, and dissolved oxygen conditions during test organism holding and acclimation will be monitored to ensure proper acclimation is obtained prior to starting the bioassay tests.

Sample Preparation

Properly refrigerated wastewater samples will brought up to test temperature prior to further test solution preparation. If the salinity of the waste solution is greater than 2 grams per liter less than that of the disposal site receiving water, salinity of the test waste solution will be adjusted with anhydrous sea salts up to the receiving water salinity. Time will be allowed for waste solution pH and salinity equilibration prior to bioassay initiation. Similarly, test control water will be adjusted to appropriate test salinity prior to test initiation.

Initial dissolved oxygen demand (IDOD) has been determined to be a problem with cannery effluent and high strength waste streams. Preliminary IDOD measurements were done at the canneries in October of 1993. The results are given in Appendix 2 of the study plan. IDOD determinations will be conducted and recorded for the samples prior to the start of the bioassays. The results of these IDOD measurements will be used to determine sample dissolved oxygen (DO) conditions and aeration procedures required for the bioassays.

Experimental Conditions

Serial dilutions using filtered natural seawater obtained from the Bodega Bay Marine Laboratory, California will be prepared by volumetric addition of diluent and high strength waste effluents from each cannery. Glass graduated cylinders and other non-contaminating labware will be used to prepare the test solutions. The permit condition requires dilutions of 100, 75, 50, 25, 10, and 5% waste concentrations, as well as a control. Based on previous bioassay results for both the high strength wastes and the joint cannery effluent discharged through the outfall, we recommend that the dilutions used be concentrations of 50, 25, 10, 5, 2.5, 1.25, 0.62, and 0.31 % waste. Control water consisting of diluent water only will also be tested. Five replicate test vessels will be prepared for each test solution and control.

Test vessels will be maintained in controlled temperature incubators or water baths and allowed to acclimate to test conditions prior to the test initiation. Temperature, salinity, pH, ammonia and DO will be measured prior to test organism assignment into the test vessels. If DO concentrations are less than 40-percent of saturation or less than 4 mg/liter in any test solution or control, aeration will be initiated sufficient to maintain adequate DO levels in all test vessels and in all test concentrations (and controls) to maintain DO concentrations at a levels sufficient to support the organisms. Test photoperiod will be controlled by automatic timers to ensure adequate light for the bioassays.

Test temperatures for the fish, crustacean, and sea urchin bioassays will be 15, 15 and 18 degrees celsius respectively. Salinity for these tests will be that of the receiving water at the disposal site. Test organisms will be randomly assigned into the test vessels. Test vessels will be covered with loose fitting glass or non-contaminating covers and placed into the temperature controlled incubators.

The bioassays will be conducted for 96 hours (4 days). Daily observations to enumerate live fish and mysids and to monitor water quality parameters will be conducted throughout the bioassays. Equal volumes of food will be added to only the mysids to reduce cannibalization of this species within the test vessels.

The effect measured in the fish and mysid bioassays is mortality as defined as: no observed movement exhibited by the test organism after gentle swirling of the test container or probing. The test endpoint for the sea urchin larvae bioassay is mortality and/or larval abnormality as compared to the control organisms.

QUALITY CONTROL AND QUALITY ASSURANCE

The quality assurance objective is to characterize the potential toxicity of each of the canneries high strength waste to marine organisms by collecting bioassay test data of known and acceptable quality. The qualifications of the laboratory and personnel conducting the tests is provided in Appendix 3. The procedures described in the Test Methods section above describe the QA/QC procedures for sampling, analytical procedures, equipment calibration, sample custody, and data reduction and analysis.

Mortality in the controls of less than 10-percent in the fish and crustacean tests and 30-percent in the sea urchin tests after 96 hours will indicate successful tests. If these criteria are not met then EPA will be consulted to determine whether additional tests should be considered. Concurrent reference toxicant tests with the fish and mysid test species will be conducted using sodium chloride and reference toxicant tests with the sea urchin will use copper sulfate solutions with test concentrations bracketing the known acute toxic concentration (LC50) for each species tested. These tests will be conducted for a 24 hour duration. If the concurrent reference toxicant test LC50 falls within ± 2 standard deviations of the testing laboratory's cumulative sum LC50 for that species the tests will be considered acceptable.

DATA ANALYSIS AND REPORTING

Test data analysis and calculations

Acute mortality and/or larval abnormality data will be used to calculate an acute median lethal (LC50) or effect (EC50) concentration. A computer program (TOXDAT) will facilitate the calculation of the 96 hour LC50 (or EC50 for the zooplankton tests) by either: Probit, Spearman-Karber, or the Trimmed Spearmean-Karber Methods. The analysis used will depend on the distribution of the mortality data obtained from these toxicity tests. These LC50 or EC50 values will then be used to calculate Limiting Permissible Concentrations (LPC's).

Reports

A report of the results of the bioassay tests will be prepared following each of the tests. The report format will be as described in the permit conditions (Sections 3.3.5.1 through 3.3.5.5). Specific information including bioassay materials and methods, sampling procedures, results, data analysis, and discussion will be included in the report. General guidance for the bioassay reports will be that of EPA (1991).

REFERENCES

American Society for Testing and Materials, ASTM. 1992. Standard Practice for Conducting Static Acute Toxicity Tests with Embryos/Larvae of Four Species of Saltwater Bivalve Molluscs. Designation E724-92. Annual Book of Standards, Vol:11.04. ASTM, Philadelphia, PA.

United States Environmental Protection Agency. 1991. Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms. Fourth Edition. EPA/600/4-90/027. September 1991. 293 pp.

United States Environmental Protection Agency, United States Army Corps of Engineers. 1991. Evaluation of Dredged Material Proposed for Ocean Disposal: Testing Manual. EPA-503/8-91/001. February, 1991.

Part II

PLAN OF STUDY FOR MODELING RE-EVALUATION

INTRODUCTION

Permit condition 3.3.5 of the Ocean Disposal Dumping Permits for StarKist Samoa and VCS Samoa Packing requires that the bioassay results be used re-evaluate the previous model predictions of dispersion of the plume created by dumping fish processing wastes at sea. The previous predictions are presented in the FEIS (EPA, 1989) and in a supplementary study (SOS, 1990). A field study of the fate of the wastes is described by Soule and Oguri (1983). A description of the previous model and the details of the past modeling results are found in Appendix B of the FEIS.

We propose to conduct the model re-evaluation in three phases:

[1] The existing model formulation, as described in the 1989 FEIS (Appendix B) will be used "as is" with model predictions evaluated using the new bioassay test results. Any differences in conclusions between earlier work and the reevaluation will be presented and discussed.

[2] The input data and assumptions used in the model will be examined and evaluated. Sensitivity studies will be done for critical parameters, including assumed values for diffusion coefficients, initial dilution, and ambient conditions. The appropriateness and applicability of previously assumed values will be discussed.

[3] A different, more sophisticated model(s), and/or modifications to the previous model, using appropriate assumptions, will be applied as an independent check of the previous model predications. The model selection will be based on the results of step [2] above. The objectives of the re-evaluation with a different model is to account for changes in vessel characteristics and operational methods and to develop a more representative model.

The previous model, based on an approach originally developed by Norman Brooks, is typically very conservative in similar applications. Other assumptions in the model are also conservative. The use of a different or modified model will allow an evaluation of the degree of conservatism being applied. The initial dilution assumptions will also be examined. The propeller stream of the vessel will be modeled, using an established model developed at Texas A&M and modified by CH2M HILL, to assess the actual degree of the initial mixing.

Conclusions and recommendations will be presented based on the independent assessment. The three phases of the model re-evaluation are described below.

MODELING METHODS

Re-evaluation of Previous Model Predictions

The results of the previous model are presented in terms of dilution (or concentration) of fish processing waste versus distance from the initial dump site. Based on the results of the bioassay tests, the distance from the dump site where the effluent is diluted to the limiting permissible concentration (LPC) level can be determined.

The previous model provided results parametricly with assumed ocean current speed, pumping rate, settling velocity, and other variables. The re-evaluation will examine the range of ambient receiving water conditions, pumping rates, and effluent characteristics for the new bioassay results to determine worst case conditions.

Appropriate changes in model input parameters, such as vessel beam, vessel speed, or pumping rate, will be incorporated but the model formulation will remain as originally developed. A verification run using identical input for a previous model run will be done to confirm the same formulation is being used. A discussion of any differences between previous predictions and those for the new bioassay test results and compliance with permit conditions will be developed from the results of this phase of the model re-evaluation.

Re-evaluation of Model Assumptions and Input

The model assumptions and input can be considered in three categories:

- Model formulation assumptions: assumptions involved in the basic formulation of the model involving the fundamental physics and mathematics used

- Model development assumptions and input: the assumptions and methodology used to chose the magnitudes of the variables describing the important physical processes

- Model execution assumptions and input: the values used for the description of ambient conditions and characteristics of the waste material.

Each of these categories of model assumptions and input will be examined and re-evaluated. Each of the categories of assumptions and input is discussed in more detail below. In addition to the direct re-evaluation of the model assumptions and inputs, the sensitivity of the model will to important variables will be assessed. The results of the model predictions, and the conclusions drawn from the previous model results (for previous bioassay tests and the new bioassay tests) will be examined and discussed in terms of model assumptions and inputs. Evaluations of the degree of conservatism in the previous model formulation and execution will be presented.

Model Formulation Assumptions. The previous model formulation was based on the approach presented by Brooks (1960), and is essentially the same basic model as CDIFF (Yearsley, 1989). The formulation developed by Brooks calculates the lateral diffusion of a discharge plume as it is advected in the longitudinal direction and does not account for longitudinal dispersion.

As initially developed by Brooks, the approach does not account for vertical diffusion, does not provide for the settlement of negatively buoyant constituents in the plume, and does not account for the dispersion of a positively buoyant plume or positively buoyant components of the discharged material. In addition the model, as implemented in the FEIS, assumes a line source of constant source strength and does not simulate the discharge from a vessel traveling in an arbitrary path for a finite length of time.

The FEIS model provides for a settling velocity by redefining the longitudinal coordinate at a downward angle defined by the relationship between the longitudinal current speed and assumed vertical settling velocity such that:

$$x' = x \bullet \cos(\theta)$$

where

$\theta = \tan(u/w_s)$

u = ambient horizontal, longitudinal velocity

w_s = settling velocity

The FEIS model also accounts for vertical diffusion by applying a concentration reduction factor based on a Fickian diffusion coefficient (K_v). This factor is applied to the calculated centerline concentration (C_{max}) by

$$C_{max} \bullet \{(H/4) \bullet (2K_v t + H^2/16)^{-0.5}\}$$

to calculate an adjusted value of C_{max} accounting for vertical diffusion, where H is the initial vertical plume dimension and t is travel time along the plume trajectory.

Each of the basic assumptions of the model and the modifications made for the FEIS model, as discussed above, will be evaluated. In particular the assumption of a continuous line source will be examined and the implications of applying the model to a source discharge of a finite time interval will be evaluated.

Model Development Assumptions. The values chosen to describe the physical processes will be evaluated. These values include the lateral and vertical diffusion coefficients. In addition the model formulation assumptions include the spatial and temporal scales over which the model predictions are used.

Model Execution Input Variables. The previous model input variables, not discussed in the model assumptions section above, include ambient current speed, initial dilution, settling velocity, and initial plume dimensions. An evaluation of the methodology and assumptions used to select the values used for these variables will be done. Changes in the values due to changes in vessel and operational procedures will be addressed. This evaluation will be extended by the sensitivity study descried below.

Model Sensitivity. The sensitivity of the model to each of input variables and to assumptions about the parameters used to describe the physical processes will be evaluated. This will be done by running the model for a range of values.

Development of Independent Model

An independent model will be developed and used to evaluate the dispersion of waste discharged from the barge. The purpose of this model is to provide a more sophisticated alternative to more realistically describe the fate and transport of the discharge. The model will, at a minimum, include the effects of diffusion in both horizontal directions (longitudinal and lateral) and will model a discharge of finite time. In addition the model will account for the spatial pattern of the discharge.

The model will use initial dilutions as determined from the size of the propeller slipstream. Vertical diffusion will be accounted for using a technique similar to that used in the FEIS model. It is anticipated that the major difference in the model predictions will be reflected in the degree of conservatism involved in the model formulations and development. Any differences in model inputs and predictions will be justified and explained.

QUALITY CONTROL AND QUALITY ASSURANCE

The objective of the quality control and quality assurance (QA/QC) effort is to provide a high level of confidence that the models are providing physically realistic predictions. QA/QC will be achieved through use of the proven models executed by staff familiar with those models. Specific QA/QC measures include: validation of model code and that the models are providing physically realistic predictions, addressing a range of potential conditions where appropriate, sensitivity analyses, and documentation and maintenance of input and output files generated during modeling activities.
The models employed in the study are mathematical representations of physical processes. The mathematical equations used are solved numerically (approximate solutions) using a digital computer. It is important that this process, which is considerably removed from the actual physical processes and behavior of the ocean, accurately simulate what happens in the ocean. The process of validation uses representative parameters for simplified system configurations to determine if the predictions reflect reality. The process of validation begins as the initial model computer code is written and continues as long as the model code is used. It is particularly important that any changes in model code be checked for validity. The final element of validation is a determination of how sensitive a model is to changes in input parameters. An extremely sensitive model probably does not provide results with a high confidence level. Sensitivity checks will be carried out for each of the models for potentially critical parameters.

Most numerical models of the type used here contain coefficients (e.g. friction factors, diffusion coefficients) that are often study site specific. Although there are generally accepted values for these coefficients, the range observed in nature is high and the models can be somewhat sensitive to the values selected. The process of calibration and verification uses measured values of forcing functions and responses to determine the appropriate coefficients for the model configuration at the study site. Typically a set of field data is used to determine the correct values to use for the coefficients. However, this is beyond the scope of the present study and there is little or no available and appropriate data for this task. In this case the model sensitivity studies, the use and justification of reasonable values for the literature and similar studies, and the incorporation of a prudent level of conservatism is required.

DATA ANALYSIS AND REPORTING

A report documenting the results of all analyses will be prepared. The report will include summaries of all input data, modeling procedures, and model results. All pertinent model results and output files (as appropriate) will be reproduced as an appendix to the report.

Model results will be presented both in tabular form and graphically (i.e. contour plots) as appropriate. The report will include: an executive summary; an introduction describing the background, rationale, and general approach of the study; a description of the methods used including model formulation and input data; a description of the model results; an evaluation of the model validity for predicting dilution and plume characteristics; and, an evaluation of the concentration of the fish processing wastes within and at the boundary of the permitted ocean dumping site.

REFERENCES

Brooks, N.H., 1960. "Diffusion of Sewage Effluent in an Ocean Current," Proceedings of the First Conference on Waste Disposal in Marine Environment, Pergamon Press, NY.

SOS Environmental and Environmental & Ocean Technology, 1990. "Mathematical/Computer Modeling of Fish Waste Disposal at an Ocean Disposal Site off Tutuila Island, American Samoa". Report prepared for StarKist Seafood and Van Camp Seafood

Soule, D.F. and M. Oguri, 1983. "A report on Ocean Disposal of Fish Processing Wastes off Pago Pago , American Samoa. Report to EPA and NOAA for StarKist Foods and Van Camp Seafood. Los Angeles, California

U.S. Environmental Protection Agency, 1989. Final Environmental Impact Statement for the Designation of an Ocean Disposal Site off Tutuila Island, American Samoa for Fish Processing Waste. EPA Region 9, San Francisco, CA.

Yearsley, J.R., 1989. "Diffusion in Near-shore and Riverine Environments," EPA 910/9-87-168. EPA Region 10, Seattle, Washington.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

RECEIVED
DEC 14 1993
CH2M HILL
SAN FRANCISCO

December 10, 1993

Steven L. Costa
Project Manager
CH2M Hill
P.O. Box 12681
Oakland, CA 94604-2681

Re: Comments to Draft Study Plans for Joint Cannery Ocean Disposal Bioassay Toxicity Tests and Modeling Re-evaluation

Dear Steve:

We have reviewed the draft study plans for the biotoxicity tests and modeling re-evaluation. Attached are comments on the bioassay toxicity tests which should be addressed before the plan will be approved. Questions regarding these comments should be addressed to Amy Wagner at (510) 412-2329. A final study plan should be submitted for approval upon resolution of these comments.

Due to the delay in submittal of the draft study plan, we are allowing the first sampling episode to occur in January 1994, rather than in November 1993, as indicated in the ocean disposal permits. Thus we approve your request that each of the subsequent three sampling episodes be delayed by the same amount to maintain the desired spacing. However, the completion date for the overall study will not be changed.

The modeling re-evaluation study plan is approved as submitted. However, as we previously discussed, the additional, more sophisticated model referenced in the plan has not been selected yet and will be submitted for EPA's review prior to its utilization.

Please call Pat Young at 415/744-1594 if you have any questions.

Sincerely,

Norman L. Lovelace, Chief
Office of Pacific Island and Native
American Programs (E-4)

cc: Jim Cox, Van Camp Seafood Company
Norman Wei, StarKist Seafood Company
Tony Tausaga, American Samoa EPA
Sheila Wiegman, American Samoa EPA

Attachment

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

DEC 0 9 1993

SUBJECT: Review of Draft Bioassay and Modeling Re-evaluation Plans for Tuna Cannery Ocean Disposal Permits

TO: Pat Young
American Samoa Program Manager

FROM: Amy Wagner
Laboratory Section

Debra Denton, Permits Issuance Section, and I have reviewed Part I (Bioassay Toxicity Tests) in the above entitled document. We do not recommend approval of the plan until the following issues are addressed or considered. Any questions concerning these comments can be adressed to me at (510) 412-2329.

1. Introduction, I-1: Considering the nature of the waste discharge, we agree that the fish processing wastes should be considered as whole effluent and not tested in the suspended particulate phase.

2. Sample Shipping and Handling, page I-2: Understanding the logistical difficulties in shipping samples from the South Pacific, it should be recognized that a 10 day hold time could result in an increase or decrease of toxicity. It is likely that the BOD will increase over time as reflected by IDOD values determined in the last toxicity tests on cannery effluent. Every effort to minimize the hold time should be made.

3. Selected Species, page I-2: Holmesimysis costata may not be an appropriate surrogate crustacean due to the low test temperature required and the crustacean's sensitivity to aeration. The use of the 96-hour static renewal acute test with Mysidopsis bahia is recommended as a more representative tropical species relevant to the study area.

4. Sample Preparation, page I-4: Artificial sea salts for brine manipulations of effluents can often cause toxicity. Use of natural seawater brine effluents (obtained from freezing or evaporating natural seawater) is recommended.

5. Experimental Conditions, I-4: The dilution series proposed seems more appropriate than the permit requirements based on toxicity seen at low concentrations of the cannery effluent. This dilution series may have to be modified after the first round of testing.

6. Experimental Conditions, I-5: The test temperatures proposed for the crustacean and sea urchin bioassays are higher than standard method requirements. Tests with M. bahia and P. vannamei are run at 20C, while tests using S. purpuratus are normally run at 12-15C.

7. Experimental Conditions, I-5: Methods for fish, mysid, and sea urchin toxicity tests should be cited (manual or reference) in this section since all test conditions (ie. static renewals, number test organisms) are not listed.

8. Quality Control and Quality Assurance, I-5: Sodium chloride is not a standard reference toxicant used in marine fish and mysid tests. In addition, this salt may cause an osmoregulatory rather than a toxicity response in the test organism causing variable sensitivity and dose-responses. Sodium dodecyl chloride, copper sulfate, or zinc sulfate are recommended reference toxicants for these test organisms.

cc: Terry Oda, Chief
Permits Issuance Section (W-5-1)

Appendix 3
SOP for Sample Collection

Standard Operating Procedures
High Strength Waste Sampling
for Bioassay Toxicity Tests

Introduction

Starkist Samoa, Inc. and VCS Samoa Packing are each required under their Ocean Disposal Dumping Permits to conduct definitive acute bioassays on their high strength waste (HSW) streams that are barged to sea for disposal at the permitted dump site. The following gives detailed procedures for collecting, preparing, and shipping samples for these analyses.

Each cannery is required to collect a composite sample of high strength waste while the waste is being transferred from the storage tanks to the barge. Currently a one gallon composite is required for the bioassay tests. The procedures described below are applicable to sampling at each of the canneries.

List of Equipment/Supplies

The following supplies will be required for collecting composite high strength waste samples and preparing them for delivery to the laboratories:

- Three (3) 1/2 to 1 gallon sampling containers
- One 1-gallon cubitainer or other appropriate container (container should be heavy-duty plastic with secure cap, <u>do not ship samples in glass containers</u>)
- Permanent marker for marking sample containers
- Cooler with ice (or refrigerator space) for storing sample
- Cooler for shipping samples (note: Cooler should be sized to hold sample(s) with sufficient room for ice.)
- Cubed ice (enough ice to fill airspace in cooler)
- Chain of Custody Forms (supplied by CH2M HILL or by laboratory conducting the analysis)

Sampling

The following describes the general sampling procedures:

1) **Collect "Grab" Samples.** Sampling should take place the day of or evening before the samples are shipped to the lab. Collect <u>three</u> 1/2 to 1-gallon grab samples from existing sampling ports in the storage tank transfer lines at the time waste is being transferred from the storage tanks to the barge. The samples should be collected at <u>10 minute intervals</u>. Record the time each grab was taken. Store all samples in coolers on ice or in a

refrigerator at a temperature of approximately 4°C. Do **NOT** store samples in a freezer or using a method that would otherwise freeze the samples.

2) **Composite Samples.** Using a permanent marker, label the 1-gallon cubitainer with the following information:
   - Facility samples were collected from
   - Date
   - Time each grab sample was collected

   Combine the three grab samples by measuring 1/3 gallon of each into the 1-gallon cubitainer. Seal the sample container by placing plastic inside the cap and taping the cap down.

3) **Complete Chain of Custody Form.** One chain-of-custody form is required for each cooler in which samples are shipped. An example of a completed chain-of-custody form is included as Attachment A, along with a blank copy. Fill out the chain-of-custody form in triplicate or copy keeping one copy and sending two with the samples to the laboratory.

Shipping

The samples should be shipped the fastest way possible to:

Dr. Kurt Kline
Advanced Biological Testing, Inc.
3150 Paradise Drive, Building 50
Tiburon, CA 94920

Phone: (415) 435-7878; Fax: (415) 435-7882

The samples from each cannery can be shipped in separate coolers or in the same cooler. Place the composite sample into the cooler in which sample(s) is to be shipped. Ice, or an equivalent means such as chemical cold packs, should be used to fill in the empty space in the cooler and keep the sample(s) cold during shipping. Do not use dry ice to ship the sample. If cubed ice is used, precautions should be taken to prevent the melted ice from leaking out of the cooler during shipping. These include taping any drain plugs in the cooler shut with duct tape or strapping tape, and "double-bagging" the ice cubes in zip-lock bags, i.e. sealing the ice cubes in one bag, then sealing the bag containing ice in a second bag. As much air as possible should be removed from the bags prior to sealing. (Too much air inside the bags will expand during flight and pop the bag open).

The chain-of-custody form should signed, placed in a zip-lock bag, and taped with duct tape to the inside of the cooler lid. The cooler should be taped securely with strapping tape or other strong packaging tape to prevent it from opening during shipping.

Attachment A
Example Chain-of-Custody Form

CH2M HILL
QUALITY ANALYTICAL LABORATORIES

CHAIN OF CUSTODY RECORD AND AGREEMENT TO PERFORM SERVICES

CH2M HILL Project #: 0PE30702.DS.BT
Purchase Order #:

Project Name: OCEAN DUMPING PERMIT HIGH STRENGTH WASTE BIOASSAY

Company Name/CH2M HILL Office: CH2M HILL /SFO

Project Manager & Phone #: Mr. [ ] Ms. [ ] Dr. [X] STEVE COSTA 510 251-2888 x2251

Report Copy to: SAME

Requested Completion Date: A.S.A.P.

Sampling Requirements: SDWA [ ] NPDES [ ] RCRA [ ] OTHER OCN

Sample Disposal: Dispose [X] Return [ ]

LAB TEST CODES

SHADED AREA - FOR LAB USE ONLY

Lab 1 # | Lab 2 # | Quote # | Kit Request # | Project # | No. of Samples | Page | of | COC Rev | Login | LIMS Ver | Ack Gen

ANALYSES REQUESTED

Sampling Date	Sampling Time	Type: COMP	Type: GRAB	Matrix: WATER	Matrix: SOIL	CLIENT SAMPLE ID (9 CHARACTERS)	# OF CONTAINERS	BIOASSAY GROUP 1	BIOASSAY GROUP 2	BIOASSAY GROUP 3	REMARKS	LAB 1 ID	LAB 2 ID
10/18	1000	X		X		STARKIST	1	X	X	X	1-1gal cubitainer ON ICE		

EXAMPLE DO NOT USE

Sampled By & Title (Please sign and print name)	Cliff Johnson CLIFF JOHNSON	Date/Time 10/18 1000	Relinquished By (Please sign and print name)		Date/Time
Received By (Please sign and print name)		Date/Time	Relinquished By (Please sign and print name)		Date/Time
Received By (Please sign and print name)		Date/Time	Relinquished By (Please sign and print name)		Date/Time
Received By (Please sign and print name)		Date/Time	Shipped Via: UPS BUS Fed-Ex Hand Other DHL	Shipping #	
Work Authorized By (Please sign and print name)		Remarks: SAMPLE IS COMPOSITE OF 3 GRAB SAMPLES TAKEN AT 10 MINUTE INTERVALS			

HAZWRAP/NESSA: Y N
QC Level: 1 2 3 Other:
COC Rec | ICE
Ana Req | TEMP
Cust Seal | Ph

Instructions and Agreement Provisions on Reverse Side

DISTRIBUTION: ORIGINAL - LAB, Yellow - LAB, Pink - Client

REV 1 FORM

CH2M HILL
QUALITY ANALYTICAL LABORATORIES

CHAIN OF CUSTODY RECORD AND AGREEMENT TO PERFORM SERVICES

CH2M HILL Project #	Purchase Order #
Project Name	
Company Name/CH2M HILL Office	
Project Manager & Phone # Mr. [ ] Ms. [ ] Dr. [ ]	Report Copy to:
Requested Completion Date:	Sampling Requirements: SDWA ☐ NPDES ☐ RCRA ☐ OTHER ____ ; Sample Disposal: Dispose ☐ Return ☐

OF CONTAINERS

LAB TEST CODES

ANALYSES REQUESTED

SHADED AREA - FOR LAB USE ONLY

Lab 1 #	Lab 2 #
Quote #	Kit Request #
Project #	
No. of Samples	Page ___ of ___
COC Rev	Login
LIMS Ver	Ack Gen

Sampling Date	Sampling Time	Type COMP	Type GRAB	Matrix WATER	Matrix SOIL	CLIENT SAMPLE ID (9 CHARACTERS)	# OF CONTAINERS	ANALYSES REQUESTED	REMARKS	LAB 1 ID	LAB 2 ID

Sampled By & Title (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time
Received By (Please sign and print name)	Date/Time	Shipped Via: UPS BUS Fed-Ex Hand Other____	Shipping #
Work Authorized By (Please sign and print name)	Remarks		

HAZWRAP/NESSA: Y N
QC Level: 1 2 3 Other:
COC Rec | ICE
Ana Req | TEMP
Cust Seal | Ph

Instructions and Agreement Provisions on Reverse Side

DISTRIBUTION: ORIGINAL - LAB, Yellow - LAB, Pink - Client
REV 11/92 FORM 340

Appendix 4
EPA Communications on Bioassay Testing

OPINAP FAX TRANSMISSION
USEPA Region 9
Office of Pacific Island and Native American Programs (E-4)
75 Hawthorne Street
San Francisco, CA 94105
FAX NO: (415) 744-1604
VERIFICATION NO: (415) 744-1599

DATE: July 7, 1995 PAGES (incl. cover): 1

TO: Kurt Kline
Advanced Biological Testing Inc.

FAX: 415/435-7882 Phone: 415/435-7878

SUBJECT: Bioassay Test of Cannery Waste on Bi-valve Larvae

FROM: Pat Young, American Samoa Program Manager Pat
USEPA Region 9
Phone: (415) 744-1594

Amy Wagner discussed with me the problems you were having with spawning the mussel larvae necessary for conducting bioassay tests on the cannery waste, and whether you should continue with the tests even though the cannery waste sample is now over 10 days old. Although the sample has been stored properly and refrigerated, we are concerned that given its high organic content and the waste's tendency to increase its ammonia content over time, no meaningful comparison or correlation of results could be made among the results of bioassay tests conducted on mussel larvae using 10-day-old cannery waste and the results obtained with the sand dab and mysid using the fresh sample. Rather than having you conduct the entire series again with the three species using new samples, and given the unrealibility of the mussel spawning, we waive the requirement to conduct the bioassay test on the mussel larvae for this round of sampling.

Should you have any questions, please feel free to call me.

cc: Steve Costa, CH2MHill
Jim Cox, Van Camp Seafoods
Norman Wei, Star-Kist Samoa
Amy Wagner, EPA Lab
Alan Ota, EPA (W-3-3)
Sheila, Wiegman, ASEPA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

September 30, 1994

1994

Steven L. Costa
Project Manager
CH2M Hill
P.O. Box 12681
Oakland, CA 94604-2681

Re: Third Bioassay Test of Ocean Disposed High-Strength Waste of StarKist Samoa, Inc. and VCS Samoa Packing Company

Dear Steve:

We have reviewed the two options proposed in your letter of September 14, 1994 for the timing of the third bioassay test required by the canneries' ocean disposal permits. We believe that information obtained during the different seasons would prove valuable. Thus, your proposal to change the schedule of the final bioassay test from December 1994 to June 1995 is approved. We understand that this will extend the term of the study beyond that stated in the permits. Since the modeling and evaluation will have been started on the first sets of data, we would expect to see the final study results by October 1995. As you know, the permits expire on August 31, 1996, and the canneries should reapply for permit renewal a few months prior to this expiration date. Because of the implications this report has for the designated ocean disposal site, we would like to receive the modeling and evaluation report with ample time to review it prior to the reapplication period.

Please call me at (415) 744-1594 if we need to discuss this further.

Sincerely,

Pat Young

Pat Young
American Samoa Program Manager
Office of Pacific Island and Native American Programs (E-4)

cc: Jim Cox, Van Camp Seafood Company
Norman Wei, StarKist Seafood Company
Tony Tausaga, American Samoa EPA
Sheila Wiegman, American Samoa EPA
Allan Ota, W-3-3
Amy Wagner, P-3-1

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

August 29, 1994

Steven L. Costa
Project Manager
CH2M Hill
P.O. Box 12681
Oakland, CA 94604-2681

Re: Comments on Bioassay Testing of Ocean Disposed High-Strength Waste of StarKist Samoa, Inc. and VCS Samoa Packing Company

Dear Steve:

We have reviewed the report of June 29, 1994 for the first of three rounds of bioassays of high-strength waste, as required by the canneries' ocean disposal permits. The report is based on two sampling events: the first was collected on February 16, 1994; and, a second sample was required and tested in March 1994, due to test failure of the echinoderms in the first sample. Your proposed changes to the study methods, as outlined in your memo of July 1, 1994, are acceptable. Enclosed is a memo from Amy Wagner of EPA's Laboratory Support Section, detailing the acceptable changes. Please call Amy at (510) 412-2329 if you have any questions on her comments.

We note that the second and third rounds of testing were scheduled for May and August 1994, and we would like to know if these tests were conducted as scheduled and, if not, the rescheduled dates, and when we can anticipate the reports on these bioassays. Please relay this information to Pat Young, American Samoa Program Manager, or if you have any questions, call her at (415) 744-1594.

Sincerely,

M. J. Lee
for Norman L. Lovelace, Chief
Office of Pacific Island and Native American Programs (E-4)

Enclosure

cc: Jim Cox, Van Camp Seafood Company
Norman Wei, StarKist Seafood Company
Tony Tausaga, American Samoa EPA
Sheila Wiegman, American Samoa EPA
Allan Ota, W-3-3
Amy Wagner, P-3-1

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX LABORATORY
1337 S. 46TH STREET BLDG 201
RICHMOND, CA 94804-4698

AUG 2 9 1994

MEMORANDUM

SUBJECT: Review of Bioassay Testing of Starkist, Samoa, Inc. and VCS Samoa Packing High Strength

FROM: HB for ALW
Amy Wagner
Laboratory Section (P-3-1)

THRU: Brenda Bettencourt
Brenda Bettencourt, Chief
Laboratory Section (P-3-1)

TO: Pat Young
OPINAP (E-4)

Allan Ota
Wetlands and Sediment Management Section (W-3-3)

At your request, I have reviewed "Results of a Bioassay Conducted on Two High Strength Waste Samples from the Van Camp and Starkist Tuna Canneries in American Samoa." The following recommendations are based on the results of the first round of testing.

1. p. 11. The salinity of the *Mysidopsis bahia* tests were 25 ppt, presumably based on the salinity of the shipping water. An effort should be made to find a supplier that raises mysids in a salinity closer to that of the discharge site, between 30-35 ppt.

2. Appendix, p. 1. It is recommended that the water quality measurements pH, dissolved oxygen, and initial salinity be measured for all samples upon receipt.

3. Appendix, Table 10. The salinities of 26-28 ppt most likely caused the high mortality in controls with the sea urchin toxicity test. If necessary, brine adjustments should be used to increase the salinity of test samples to the test method requirements of 30 $\pm$ 2 ppt.

4. To reduce salinity elevation throughout the tests, an attempt should be made to cover test containers to reduce evaporation.

Based on the results of these tests, the following changes in the bioassay methods recommended by CH2M Hill in the cover memo are acceptable.

1. The series of the concentrations for toxicity tests can be reduced to 2.0%, 1.0%, 0.5%, 0.25%, 0.125%, and 0.0625% instead of the suggested series.

2. *Mytilus edulis* can be used instead of *Strongylocentrotus purpuratus* as the third test organism. The oyster *Crassostrea virginica* may be substituted for the mussel test during the months when mussels cannot be spawned.

3. Aeration should be provided in the mussel test containers due to high biological oxygen demand of the effluent. In addition to a control with aeration, a control without aeration should be run. A t-test should be used to determine if the there is any significant effect of aeration.

Any questions on the comments can be addressed to me at (510) 412-2329.

cc: Jeff Rosenbloom, Chief
Wetlands and Sediment Management Section (W-3-3)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

RECEIVED
DEC 14 1993
CH2M HILL
SAN FRANCISCO

December 10, 1993

Steven L. Costa
Project Manager
CH2M Hill
P.O. Box 12681
Oakland, CA 94604-2681

Re: Comments to Draft Study Plans for Joint Cannery Ocean Disposal Bioassay Toxicity Tests and Modeling Re-evaluation

Dear Steve:

We have reviewed the draft study plans for the biotoxicity tests and modeling re-evaluation. Attached are comments on the bioassay toxicity tests which should be addressed before the plan will be approved. Questions regarding these comments should be addressed to Amy Wagner at (510) 412-2329. A final study plan should be submitted for approval upon resolution of these comments.

Due to the delay in submittal of the draft study plan, we are allowing the first sampling episode to occur in January 1994, rather than in November 1993, as indicated in the ocean disposal permits. Thus we approve your request that each of the subsequent three sampling episodes be delayed by the same amount to maintain the desired spacing. However, the completion date for the overall study will not be changed.

The modeling re-evaluation study plan is approved as submitted. However, as we previously discussed, the additional, more sophisticated model referenced in the plan has not been selected yet and will be submitted for EPA's review prior to its utilization.

Please call Pat Young at 415/744-1594 if you have any questions.

Sincerely,

Norman L. Lovelace, Chief
Office of Pacific Island and Native
American Programs (E-4)

cc: Jim Cox, Van Camp Seafood Company
Norman Wei, StarKist Seafood Company
Tony Tausaga, American Samoa EPA
Sheila Wiegman, American Samoa EPA

Attachment

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

DEC 09 1993

SUBJECT: Review of Draft Bioassay and Modeling Re-evaluation Plans for Tuna Cannery Ocean Disposal Permits

TO: Pat Young
American Samoa Program Manager

FROM: Amy Wagner
Laboratory Section

Debra Denton, Permits Issuance Section, and I have reviewed Part I (Bioassay Toxicity Tests) in the above entitled document. We do not recommend approval of the plan until the following issues are addressed or considered. Any questions concerning these comments can be adressed to me at (510) 412-2329.

1. Introduction, I-1: Considering the nature of the waste discharge, we agree that the fish processing wastes should be considered as whole effluent and not tested in the suspended particulate phase.

2. Sample Shipping and Handling, page I-2: Understanding the logistical difficulties in shipping samples from the South Pacific, it should be recognized that a 10 day hold time could result in an increase or decrease of toxicity. It is likely that the BOD will increase over time as reflected by IDOD values determined in the last toxicity tests on cannery effluent. Every effort to minimize the hold time should be made.

3. Selected Species, page I-2: Holmesimysis costata may not be an appropriate surrogate crustacean due to the low test temperature required and the crustacean's sensitivity to aeration. The use of the 96-hour static renewal acute test with Mysidopsis bahia is recommended as a more representative tropical species relevant to the study area.

4. Sample Preparation, page I-4: Artificial sea salts for brine manipulations of effluents can often cause toxicity. Use of natural seawater brine effluents (obtained from freezing or evaporating natural seawater) is recommended.

5. Experimental Conditions, I-4: The dilution series proposed seems more appropriate than the permit requirements based on toxicity seen at low concentrations of the cannery effluent. This dilution series may have to be modified after the first round of testing.

6. Experimental Conditions, I-5: The test temperatures proposed for the crustacean and sea urchin bioassays are higher than standard method requirements. Tests with M. bahia and P. vannamei are run at 20C, while tests using S. purpuratus are normally run at 12-15C.

7.Experimental Conditions, I-5: Methods for fish, mysid, and sea urchin toxicity tests should be cited (manual or reference) in this section since all test conditions (ie. static renewals, number test organisms) are not listed.

8.Quality Control and Quality Assurance, I-5: Sodium chloride is not a standard reference toxicant used in marine fish and mysid tests. In addition, this salt may cause an osmoregulatory rather than a toxicity response in the test organism causing variable sensitivity and dose-responses. Sodium dodecyl chloride, copper sulfate, or zinc sulfate are recommended reference toxicants for these test organisms.

cc: Terry Oda, Chief
Permits Issuance Section (W-5-1)

Appendix 5
Laboratory Results Submitted by ABT - First Test

RESULTS OF A BIOASSAY CONDUCTED ON TWO HIGH STRENGTH WASTE SAMPLES FROM THE VAN CAMP AND STARKIST TUNA CANNERIES IN AMERICAN SAMOA

Prepared for:

CH2M Hill California, Inc.
1111 Broadway
Oakland, CA 94607
Project # PDX 30702

Prepared by:

Advanced Biological Testing Inc.
98 Main St., # 419
Tiburon, Ca. 94920

June 29, 1994

Ref: 9309-2

1.0 INTRODUCTION

At the request of CH2M Hill (Project # PDX 30702), Advanced Biological Testing conducted acute effluent bioassay testing on *Mysidopsis bahia*, *Mytilus edulis*, *Strongylocentrotus purpuratus* and *Citharichthys stigmaeus* using high strength wastes (HSW) collected separately from the Van Camp (HSW-1) and Starkist (HSW-2) tuna canneries in American Samoa. The study was run using methods generally specified in EPA 1991 and in a Sampling and Testing Plan submitted to the EPA.

The study was conducted at the Advanced Biological Testing Laboratory in Tiburon, California, and was managed by Mr. Mark Fisler.

2.0
METHODS

2.1 EFFLUENT SAMPLING

The high strength wastes were sampled as composites on February 16, 1994 by personnel from CH2M Hill. Due to shipping and airline scheduling problems, frequently encountered in this region, the sample was received by the laboratory on February 19, 1994. Two five gallon carboys were provided from each cannery defined as HSW-1 (VCS) and HSW-2 (SK) and were maintained in ice-filled coolers from the date of sampling until laboratory receipt. The sample were at 2-3°C upon receipt.

Due to the test failure in the echinoderms, both of the HSW were resampled on March 30, 1994, and shipped to ABT arriving on April 4, 1994.

2.2 SAMPLE PREPARATION

2.2.1 Testing on the speckled sanddab, *Citharichthys stigmaeus*

After extensive discussions with the EPA regarding the proposed testing concentrations, the high strength wastes were tested at eight concentrations starting from 3.0% and dropping using a 50% dilution factor. The final concentrations were 3.0, 1.5, 1.25, 0.8, 0.4, 0.2, 0.1 and 0.05% as vol:vol dilutions in seawater. The diluent was filtered seawater from the Bodega Bay Marine Laboratory. The dilutions were brought up to the test temperature (14°C) and aerated continuously. Based upon data provided by CH2M Hill, and subsequently supported by information from the EPA, these effluents have an extremely high biological oxygen demand, therefore aeration was carried out from the beginning of the test.

A reference toxicant was run using concentrations of the toxicant Sodium Dodecyl Sulfonate (SDS) made up as a 2 grams per liter stock solution in distilled water. The tested concentrations were set at 25, 12.5, 6.25, 3.1, and 1.6 mg/L in 30 ppt seawater in a 24 hour test.

2.2.2 Testing on the mysid, *Mysidopsis bahia*

Both of the high strength wastes were tested twice, once in a concentration series of 25, 12.5, 6.25, 3.1, 1.6, 0.8, and 0.4% vol:vol in seawater, and after discussions with the EPA, a second time at a lower concentration series of 1.6, 0.8, 0.4, 0.2, 0.1 and 0.05% vol:vol dilutions. The diluent was filtered seawater from the Bodega Bay Marine Laboratory. The dilutions were brought up to the test temperature (20°C) and aerated continuously.

A reference toxicant was run using concentrations of the toxicant Sodium Dodecyl Sulfonate (SDS) made up as a 2 grams per liter stock solution in distilled water. The tested concentrations were set at 20, 10, 5, 2.5 and 1.25 mg/L in 30 ppt seawater in a 96 hour test.

2.2.3 Echinoderm and Bivalve Larval Bioassay

Test solutions used in the bioassays were prepared using San Francisco Bay seawater at 28 ppt in serial dilution (0.5) to create 0.08%, 0.15%, 0.3%, 0.6% and 1.2% test concentrations for the bioassays. The echinoderm test failed control survival in two testing attempts using the initial HSW delivered on February 19, 1994. A second sample was requested from each cannery which was delivered on April 4, 1994. The echinoderm test again marginally failed the controls and the results of the study are presented for information. The bivalve study conducted concurrently with the echinoderm bioassay passed the control criteria.

The reference toxicant for the echinoderm and bivalve larval bioassays was copper at test concentrations of 0.56, 3.2, 10, 32, and 56 µg/L.

2.2.4 *Citharichthys stigmaeus*

The bioassays were carried out on juvenile *Citharichthys stigmaeus*, supplied by J. Brezina and Associates in Dillon Beach, California. The animals were received at ABT on February 19, 1994. The test conditions are summarized in Table 1. Five replicates of each concentration were tested with ten juvenile fish per replicate. Water quality was monitored daily as initial quality on Day 0 and final water quality on Days 1-4. Parameters measured included dissolved oxygen, pH, salinity, total ammonia, and temperature.

2.2.5 *Mysidopsis bahia*

The first bioassay was carried out on 7-10 day old larval *Mysidopsis bahia*, supplied by J. Brezina and Associates in Dillon Beach, California. The animals were received at ABT on February 19, 1994. The test conditions for this test are summarized in Table 2. The second test was carried out on larval mysids supplied by Aquatox from Hot Springs, Arkansas. The animals were received at ABT on February 26, 1994. The test conditions for the second test are summarized in Table 3.

Five replicates of each concentration were tested with ten larval mysids per replicate. Water quality was monitored daily as initial quality on Day 0 and final water quality on Days 1-4. Parameters measured included dissolved oxygen, pH, salinity, total ammonia, and temperature.

2.2.6 Echinoderm Larval Development Test

The echinoderm larvae survival and development test followed draft ASTM methods (ASTM, 1994). Purple urchins, *Strongylocentrotus purpuratus,* were obtained from A. K. Siewers, Santa Cruz, California. Adults were induced to spawn by intercoelomic injection of 0.5M KCl. Released eggs were placed in individual containers of filtered seawater, and sperm was collected dry and held on ice. Gametes were mixed and allowed to fertilize for up to two hours. Fertilized eggs were then separated from sperm and debris by filtering the suspension at 20 µm. Egg stock density was estimated by counting an aliquot of dilute stock concentrate. Equal volumes of concentrate were added to each replicate to an initial density of 15-30 embryos per mL. Initial stocking density was confirmed by counting a 5 mL aliquot from at least three control replicates.

Testing was conducted at 16 ± 2°C under a 14 hour light and 10 hour dark photoperiod. Temperature, pH, dissolved oxygen, and salinity were recorded at 0, 24, 48 and 72 hours in water quality replicates. Total ammonia was measured in the 1.2% sample at 0 and 48 hours. At the end of the exposure period, a 5 mL sub-sample was taken from each test replicate and preserved with buffered formalin. Sub-samples were counted in a Sedgwick-Rafter cell, and the total number of normal and abnormal larvae were counted.

2.2.7 *Mytilus edulis* Larval Survival and Development Test

The bivalve larvae survival and development test was run in parallel with the echinoderm using the second set of effluents. The test followed methods in ASTM (1993). Bay mussels, *Mytilus edulis,* were obtained from A. K. Siewers, Santa Cruz, California. Adults were induced to spawn by heat shocking. Released gametes were placed in individual containers of filtered seawater and examined for viability. Gametes were mixed and allowed to fertilize for up to two hours, under gentle aeration. Fertilized eggs were then separated from sperm and debris by filtering the suspension at 20 µm. Egg stock density was estimated by counting an aliquot of dilute stock concentrate. Equal volumes of concentrate were added to each replicate to an initial density of

15-30 embryos per mL. Initial stocking density was confirmed by counting a 5 mL aliquot from at least three control replicates.

Testing was conducted at 16 ± 2°C under a 14 hour light and 10 hour dark photoperiod. Temperature, pH, dissolved oxygen, and salinity were recorded at 0 and 48 hours; temperature was also recorded at 24 hours. Total ammonia was measured in 1.2% sample at 0 and 48 hours. At the end of the exposure period, a 5 mL sub-sample was taken from each test replicate and preserved with buffered formalin. Sub-samples were counted in a Sedgwick-Rafter cell, and the total number of normal and abnormal larvae were counted.

Dissolved oxygen levels of test solutions of HSW-2 fell below 60% saturation in both the bivalve and echinoderm tests. Gentle aeration was started on Day 1, and continued for the duration of the tests. To assess the effects of aeration, control replicates 4 and 5 were aerated beginning on Day 1 for both the bivalve and echinoderm tests. No statistical differences were observed between aerated and unaerated control replicates.

2.3 STATISTICAL ANALYSIS

At the conclusion of the test, the survival data were evaluated statistically using ToxCalc™ to determine ECp, NOEC, and TU values where appropriate. ToxCalc™ is a comprehensive statistical application that follows standard guidelines for acute and chronic toxicity data analysis.

At the conclusion of the echinoderm tests, data were evaluated statistically to estimate the LC50 and IC50 values for the elutriate tests. The LC50 and IC50 values were estimated using the Probit or the Linear Interpolation (Bootstrap) Method.

The LC50 and the IC50 for the bivalve larvae copper reference toxicant test were both within two standard deviations of the laboratory means of 26.3 µg/L and 8.9 µg/L, respectively, indicating normal sensitivity of the test organisms. No laboratory means for the echinoderm larvae copper reference toxicant test have yet been established.

Statistical effects can be measured by the ECp, the estimated concentration that causes any effect, either lethal (LC) or sublethal (IC), on p% of the test population. The LCp is the point estimate of the concentration at which a lethal effect is observed in p% of the test organisms. ECp values include 95% confidence limits if available.

The NOEC (No Observable Effect Concentration) is the highest tested concentration at which mortality is not significantly different from the control.

3.0
RESULTS

Water quality measurements were within the acceptable limits provided in EPA 1991. Temperature was maintained at 20 ± 2°C; pH remained relatively stable, and the salinity increased slightly as would be expected in a static test. The dissolved oxygen did drop as projected at approximately 1 hour after test initiation in all of the concentration even with supplemental aeration therefore aeration was maintained in all chambers for the duration of the test. Ammonia was measured in two replicates from each concentration daily and was a potentially significant toxic component of the test for all concentrations.

3.1 *Citharichthys stigmaeus*

The LC50 for HSW-1 was 0.59%. Mortality in the effluent was rapid at the highest concentrations, occurring in 2-4 hours. There was significant mortality at 3.0, 1.5, and 0.8% concentrations compared to the control at 96 hours. The NOEC was 0.4% and the LOEC was 0.8%

The LC50 for HSW-2 was 0.27%. Mortality in the effluent was rapid at the highest concentrations, generally occurring in 2-4 hours. There was significant mortality at 3, 1.5, 0.8 and 0.4% concentrations compared to the control at 96 hours. The NOEC was 0.2%, and the LOEC was 0.4%.

The reference toxicant test required the use of the Trimmed Spearman-Karber method and generated an LC50 of 4.34 mg/L, an NOEC of 3.1 mg/L, and an LOEC of 6.25 mg/L. This is the first reference toxicant test on *Citharichthys* at this laboratory, therefore no database has been established by this laboratory.

3.2 *Mysidopsis bahia*

The LC50 results for both HSW effluents in the initial tests were <0.4%. Based upon the fact that no definitive LC50 could be calculated, the tests were rerun as described in the methods.

The LC50 for HSW-1 was 0.59%. Mortality in the 1.6% and 0.8% effluent was incomplete at 24 hours. At 96 hours, there was significant mortality at 1.6, 0.8, 0.4, and 0.1% concentrations compared to the control. The NOEC was 0.05% and the LOEC was 0.1%.

In the second test series the LC50 for HSW-2 was 0.12%. Mortality in the 1.6% and 0.8% effluent was complete at 24 hours. There was significant mortality at 96 hours in the 1.6, 0.8, 0.4, 0.2 and 0.1% concentrations compared to the control. The NOEC was 0.05%, and the LOEC was 0.1%.

The reference toxicant test had an LC50 of 8.90 mg/L, with an NOEC of <1.25 mg/L and an LOEC of 1.25 mg/L. This is the first reference toxicant test on *Mysidopsis* at this laboratory, therefore no database has been established.

3.3 ECHINODERM LARVAL BIOASSAY

Control survival was marginal and unacceptable according to the protocol at 64.4% with 5.7% abnormal development. Total survival was relatively high and equal to control survival in all concentrations, however all of the embryos were abnormally developed at 0.15% to 1.2% in HSW-1 and from 0.08% to 1.2% in HSW-2. The LC50 for both effluents was greater than 1.2% however the IC50 was 0.1% for HSW-1 and <0.08% for HSW-2.

The reference toxicant analysis yielded an LC50 of 11.8 µg/L and an IC50 of 10.1 µg/L. The use of the echinoderm larval bioassay is still limited and no data is available for comparison.

3.4 BIVALVE LARVAL BIOASSAY

Control survival was acceptable at 98.1% with 6.3% abnormal development. Total survival was relatively high in all concentrations, however all of the embryos were abnormally developed at 0.15% to 1.2% in HSW-1 and HSW-2. The LC50 for both effluents was greater than 1.2% however the IC50s were <0.08% for both HSW-1 and HSW-2.

The LC50 and IC50 for the bivalve larvae copper reference toxicant test were both within two standard deviations of the laboratory means of 26.3 µg/L and 8.9 µg/L, respectively, indicating normal sensitivity of the test organisms.

3.5 AMMONIA MEASUREMENTS

Ammonia in both of the HSW was very high. When measured in a 25% dilution in seawater, ammonia levels ranged from 160 to 180 mg/L. If converted to the 100% concentration, the ammonia level would be above 640 mg/L. Tested concentrations in the *Citharichthys* bioassay ranged from 0.08 to 0.17 mg/L in the lowest concentration (0.05%) to 3.44 to 9.65 mg/L in the 3.0% dilution. At each test concentration, HSW-2 generated the higher ammonia levels. The toxicity of ammonia to sanddabs is well documented and the measured levels in the three highest concentrations in HSW-2 and the two highest concentrations in HSW-1 were sufficient to cause toxicity in the test animals in 24 hours. The mysid test results appear to indicate a slightly higher tolerance to ammonia as has been shown in the literature.

TABLE 1

Bioassay Procedure And Organism Data
For the Survival Bioassay
Using *Citharichthys stigmaeus* (U.S. EPA 1991)

Parameter	Data
Test Species	*Citharichthys stigmaeus*
Supplier	J. Brezina and Associates
Collection location	Tomales Bay
Date Acquired	2/19/94
Acclimation Time	24 hours
Acclimation Water	30 ppt seawater
Acclimation Temperature	15±2°C
Age group	Juveniles, 3-5 cm TL
Sample Identification	
Sample ID(s)	940219-1, -2
Date Sampled	2/16/94
Date Received at ABT	2/19/94
Volume Received	Ten gallons
Sample Storage Conditions	4°C in the dark
Test Procedures	
Type; Duration	96 hour static acute, renewal at 48 hours
Test Dates	2/19/94 to 2/23/94
Control Water	Bodega Bay seawater
Test Temperature	15 ± 1°C
Test Photoperiod	16 L : 8 D
Initial Salinity	30 ± 2 ppt
Test Chamber	20 L polyethylene chamber
Animals/Replicate	10 animals/replicate
Exposure Volume	5 L
Replicates/Treatment	5
Feeding	None
Deviations from procedures	Due to aeration, salinity increased throughout test.

TABLE 2

Bioassay Procedure And Organism Data
For the Survival Bioassay
Using *Mysidopsis bahia* (U.S. EPA 1991)

Parameter	Data
Test Species	*Mysidopsis bahia*
Supplier	J. Brezina and Associates
Date Acquired	2/19/94
Acclimation Time	overnight
Acclimation Water	Shipping water
Acclimation Temperature	20 ± 2°C
Age group	larvae
Sample Identification	
Sample ID(s)	940219-1, -2
Date Sampled	2/16/94
Date Received at ABT	2/19/94
Volume Received	Ten gallons
Sample Storage Conditions	4°C in the dark
Test Procedures	
Type; Duration	Acute; static; renewal at 48 hours
Test Dates	2/19/94 to 2/23/94
Control Water	Bodega Bay seawater
Test Temperature	20 ± 2°C
Test Photoperiod	14 L : 10 D
Initial Salinity	25 ppt
Test Chamber	1000 mL jars
Animals/Replicate	10 animal/replicate
Exposure Volume	500 mL
Replicates/Treatment	5
Feeding	Brine shrimp (24 hr old nauplii)
Deviations from procedures	Due to aeration, salinity increased throughout test

TABLE 3

**Bioassay Procedure And Organism Data
For the Survival Bioassay
Using *Mysidopsis bahia* (U.S. EPA 1991)**

Parameter	Data
Test Species	*Mysidopsis bahia*
Supplier	Aquatox
Date Acquired	2/26/94
Acclimation Time	Overnight
Acclimation Water	Shipping water
Acclimation Temperature	20 ± 2°C
Age group	larvae
Sample Identification	
Sample ID(s)	940219-1, -2
Date Sampled	2/16/94
Date Received at ABT	2/19/94
Volume Received	Ten gallons
Sample Storage Conditions	4°C in the dark
Test Procedures	
Type; Duration	Acute; static; renewal at 48 hours
Test Dates	2/27/94 to 3/2/94
Control Water	Bodega Bay seawater
Test Temperature	20 ± 2°C
Test Photoperiod	14 L : 10 D
Initial Salinity	25 ppt
Test Chamber	1000 mL jars
Animals/Replicate	10 animal/replicate
Exposure Volume	500 mL
Replicates/Treatment	5
Feeding	Brine shrimp (24 hr old nauplii)
Deviations from procedures	Due to aeration, salinity increased throughout test

TABLE 4

Bioassay Procedure And Organism Data For The Bioassay Using Larvae of *Strongylocentrotus purpuratus* (modified ASTM 1994)

Parameter	Data
Test Species	*Strongylocentrotus purpuratus*
Supplier	A.K. Siewers, Santa Cruz, CA
Date Acquired	4/7/94
Acclimation Time	None
Acclimation Water	Not applicable
Acclimation Temperature	Not applicable
Age group	Fertilized embryos, 2 hours
Sample Identification	
Sample ID(s)	940404-3, -4
Date Sampled	3/30/94
Date Received at ABT	4/4/94
Volume Received	Two liters
Sample Storage Conditions	4°C in the dark
Test Procedures	
Type; Duration	Acute/static; 96 hours
Test Dates	4/7/94 to 4/11/94
Control Water	San Francisco Bay seawater, 0.45 µm filtered and uv-sterilized
Test Temperature	16 ± 2°C
Test Photoperiod	14 L : 10 D
Salinity	30 ± 2 ppt
Test Chamber	125 mL beakers
Animals/Replicate	Approximately 30 embryos per mL
Exposure Volume	100 mL
Replicates/Treatment	5
Feeding	None
Deviations from procedures	Chambers were gently aerated with low bubble aeration

TABLE 5

Bioassay Procedure And Organism Data For The 48 Hour Bioassay Using Larvae of *Mytilus edulis* (ASTM 1993)

Parameter	Data
Test Species	*Mytilus edulis*
Supplier	A.K. Siewers, Santa Cruz, CA
Date Acquired	4/7/94
Acclimation Time	None
Acclimation Water	Not applicable
Acclimation Temperature	Not applicable
Age group	Fertilized embryos, 2 hours
Sample Identification	
Sample ID(s)	940404-3,-4
Date Sampled	3/30/94
Date Received at ABT	4/4/94
Volume Received	Two liters
Sample Storage Conditions	4°C in the dark
Test Procedures	
Type; Duration	Acute; static; 48 hours
Test Dates	4/7/94 to 4/9/94
Control Water	San Francisco Bay seawater, 0.45 µm filtered and uv-sterilized
Test Temperature	16 ± 2°C
Test Photoperiod	14 L : 10 D
Salinity	30 ± 2 ppt
Test Chamber	125 mL beakers
Animals/Replicate	Approximately 30 embryos per mL
Exposure Volume	100 mL
Replicates/Treatment	3
Feeding	None
Deviations from procedures	Chambers were gently aerated with low bubble aeration

TABLE 6

SUMMARY OF RESULTS
FOR THE HIGH STRENGTH WASTE BIOASSAYS

Species	Test	Endpoint	HSW-1	HSW-2
Citharichthys stigmaeus	96 hr static	LC50	0.59%	0.27%
Mysidopsis bahia	96 hr static	LC50	0.59%	0.12%
Strongylocentrotus purpuratus	96 hr static	LC50	>1.2%	>1.2%
		IC50	0.10%	<0.08%
Mytilus edulis	48 hr static	LC50	>1.2%	>1.2%
		IC50	<0.08%	<0.08%

Note:
HSW-1: Van Camp
HSW-2: Starkist

TABLE 7

SUMMARY OF RESULTS FOR THE REFERENCE TOXICANT (S.D.S.) TEST

Citharichthys stigmaeus

Concentration (mg/L)	% Survival	ECp (mg/L)		NOEC (mg/L)	LOEC (mg/L)
Control	93.3	**EC50**	4.3449	3.1	6.25
1.6	80.0				
3.1	100.0				
6.2	0.0				
12.5	0.0				
25	0.0				

Mysidopsis bahia

Concentration (mg/L)	% Survival	ECp (mg/L)		NOEC (mg/L)	LOEC (mg/L)
Control	90.0	**EC50**	8.90 (3.04-69.22)	<1.25	1.25
1.25	70.0				
2.5	56.7				
5	46.7				
10	46.7				
20	36.7				

*	Statistically significant.
ICp/LCp:	Inhibition/Lethal Concentration for p% of the organisms.
NOEC:	No Observable Effect Concentration.
TU:	100%/NOEC.

4.0 REFERENCES

U.S. EPA. 1991. Methods for measuring acute toxicity of effluents to freshwater and marine organisms, 4th ed. EPA 600/4-90/027, September, 1991.

ASTM. 1993. Annual Book of Standards. Vol. 11.04. Standard guide for conducting static acute toxicity tests starting with embryos of four species of saltwater bivalve mollusca. E-724-89.

ASTM. 1994. Annual Book of ASTM Standards Vol. 11.04. Guide for conducting static acute toxicity tests with echinoid embryos. Proposed Standard in review.

APPENDIX A

ANALYTICAL DATA

APPENDIX TABLE 1

SAMPLE WATER QUALITY

Date	Day	Sample	pH (units)	DO (mg/L)	Total NH3 (mg/L)	Initial Salinity (ppt)
4/7/94	0	HSW-1, 1.2%	7.62	8.0	62.5	26
	0	HSW-2, 1.2%	6.87	7.9	51.6	26
4/9/94	2	HSW-1, 1.2%	-	-	26.4	-
	2	HSW-2, 1.2%	-	-	41.2	-
4/11/94	4	HSW-1, 1.2%	-	-	33.5	-
	4	HSW-2, 1.2%	-	-	41.9	-

APPENDIX TABLE 2

Citharichthys stigmaeus
WATER QUALITY MEASUREMENTS FOR EFFLUENT TEST
HSW-1

Concentration (%)	Rep	Day 0 pH	DO	NH3	°C	Sal	Day 1 pH	DO	NH3	°C	Sal	Day 2 pH	DO	NH3	°C	Sal	Day 3 pH	DO	NH3	°C	Sal	Day 4 pH	DO	NH3	°C	Sal
Control	1	8.02	6.2	0.02	14.0	32.0	8.07	5.5	0.01	13.2	31.5	8.08	5.5		13.8	32.9	8.03	6.0		14.0	35.0	8.06	6.1	0.02	14.4	36.0
	2						8.11	5.8		13.7	31.0	8.13	5.6	0.12	14.2	31.7	8.12	6.0		14.3	33.0	8.13	6.1		15.0	33.0
	3						8.10	6.0		13.8	30.9	8.12	5.7		14.2	31.8	8.11	6.0		14.4	32.0	8.12	5.8		15.2	33.0
	4						8.10	6.0		13.2	31.6	8.13	5.7		13.6	33.1	8.11	6.0	<0.10	13.9	35.0	8.13	5.6		14.6	36.0
	5						8.10	6.0		13.3	31.7	8.12	5.6		13.9	33.3	8.12	6.0		14.0	34.0	8.13	5.8		14.7	37.0
0.05	1	8.00	6.3	0.19	14.0	32.2	8.04	6.0	0.08	13.5	33.8	8.07	5.6		13.9	36.2	8.07	6.0		14.0	38.0	8.07	5.8	0.10	14.8	40.0
	2						8.03	6.0		13.6	33.8	8.07	5.5	0.05	13.9	36.4	8.04	6.0		14.1	38.0	8.06	5.6		14.7	40.0
	3						8.05	6.0		13.5	32.7	8.10	5.5		14.1	33.6	8.08	6.0		14.2	35.0	8.10	5.6		14.6	35.0
	4						8.01	6.0		13.5	32.3	8.07	5.6		14.1	33.4	8.06	6.0	<0.10	14.2	34.0	8.04	5.8		14.7	35.0
	5						8.05	5.9		13.6	33.1	8.09	5.6		14.1	34.1	8.09	6.0		14.2	35.0	8.10	5.8		14.9	36.0
0.1	1	8.01	6.2	0.25	14.0	32.1	8.06	6.0	0.13	13.5	31.8	8.12	5.6		13.9	32.6	8.11	6.0		14.1	34.0	8.13	5.8	0.12	14.9	34.0
	2						8.03	5.9		13.8	31.7	8.10	5.7	0.08	14.2	32.6	8.10	6.0		14.4	33.0	8.10	5.8		14.9	34.0
	3						8.01	5.8		13.3	32.8	8.08	5.7		13.8	34.8	8.06	5.9		14.0	37.0	8.06	5.6		14.4	39.0
	4						8.04	5.9		13.8	32.6	8.12	5.8		14.5	33.9	8.11	6.0	<0.10	14.6	35.0	8.11	5.7		14.9	36.0
0.2	1	8.01	6.0	0.54	14.0	32.1	8.04	5.7	0.20	14.2	30.0	8.14	5.9		14.4	31.1	8.13	6.0		14.3	32.0	8.13	6.0	0.17	14.9	34.0
	2						8.01	5.8		14.1	29.9	8.14	5.8	0.17	14.5	30.5	8.16	6.0		14.6	31.0	8.16	5.9		14.9	32.0
	3						7.98	5.8		13.9	29.8	8.12	5.8		14.2	30.3	8.13	5.9		14.9	31.0	8.14	5.9		15.0	32.0
	4						8.02	5.8		13.9	29.8	8.15	5.8		14.2	30.5	8.15	6.3	NT	14.9	31.0	8.16	5.8		15.0	32.0
	5						8.03	5.8		13.8	29.8	8.13	5.8		14.2	30.5	8.15	6.3		14.9	31.0	8.17	5.8		15.0	32.0
0.4	1	7.93	6.1	0.89	14.0	32.0	7.95	5.4	0.33	13.7	30.1	8.12	5.4		14.2	30.8	8.14	6.3		14.3	32.0	8.17	5.8	0.31	15.0	32.0
	2						7.98	5.6		14.4	30.2	8.13	5.8	0.25	14.8	31.1	8.17	6.3		14.9	32.0	8.18	5.8		14.7	33.0
	3						8.00	5.9		14.4	30.2	8.15	5.7		14.3	31.6	8.18	6.3		14.6	33.0	8.06	5.8		14.6	34.0
	4						7.76	4.6		14.0	29.9	8.06	5.8		14.5	30.3	8.09	6.2	0.17	14.7	31.0	8.11	5.8		14.6	36.0
	5						7.93	5.2		13.5	30.4	8.11	5.6		14.0	31.4	8.13	6.2		14.0	32.0	8.19	5.6		14.3	34.0
0.8	1	7.68	6.1	2.01	14.0	32.0	7.89	5.2	0.64	13.7	30.8	8.15	5.6		14.1	31.7	8.15	6.2		14.2	33.0	8.10	5.8	0.51	14.7	33.0
	3						7.82	5.1		13.1	31.2	8.09	5.6	0.40	13.7	32.6	8.06	6.3		13.90	34.0	8.10	5.8		14.20	36.0
	4						7.95	5.4		14.1	30.8	8.16	5.5		14.5	32.0	8.17	6.4	0.48	14.3	34.0	8.18	5.8		14.4	35.0
	5						7.88	5.4		13.2	31.5	8.13	5.7		14.5	32.7	8.16	6.3		14.5	34.0	8.21	5.8		14.3	35.0
1.5	1	7.51	6.0	3.56	14.0	32.2	7.83	5.2	1.43	13.3	32.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.76	4.8		13.5	31.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.75	5.0		12.9	32.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.76	5.2		12.9	32.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.76	5.1		12.9	32.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3.0	1	7.23	5.9	11.1	14.0	32.1	7.85	5.6	3.44	13.6	33.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.74	4.6		13.9	33.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.81	5.0		13.9	33.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.75	4.7		14.1	33.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.81	5.0		19.2	33.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Min		7.23	5.9	0.02	14.0	32.0	7.74	4.6	0.01	12.9	29.8	8.06	5.4	0.05	13.6	30.3	8.03	5.9	<0.10	13.9	31.0	8.04	5.6	0.02	14.2	32.0
Max		8.02	6.3	11.1	14.0	32.2	8.11	6.0	3.44	19.2	33.8	8.16	5.9	0.40	14.8	36.4	8.18	6.4	0.48	14.9	38.0	8.21	6.1	0.51	15.2	40.0

Note: — = All animals dead.
NT = Not taken.
0.1 replicate 5 not stocked.
0.8 replicate 2 lost due to lab error.

APPENDIX TABLE 2 (Cont'd)

Citharichthys stigmaeus
WATER QUALITY MEASUREMENTS FOR EFFLUENT TEST
HSW-2

Concentration (%)	Rep	Day 0					Day 1					Day 2					Day 3					Day 4				
		pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal
Control	1	8.02	6.2	0.02	14.0	32.0	8.08	5.5	0.01	13.2	31.5	8.02	5.5		13.8	32.9	8.03	6.0		14.0	35.0	8.06	6.1	0.02	14.4	36.0
	2						8.11	5.8		13.7	31.0	8.13	5.6	0.12	14.2	31.7	8.12	6.0		14.3	33.0	8.13	6.1		15.0	33.0
	3						8.10	6.0		13.8	30.9	8.12	5.7		14.2	31.8	8.11	6.0		14.4	32.0	8.12	5.8		15.2	33.0
	4						8.10	6.0		13.2	31.6	8.13	5.7		13.6	33.1	8.11	6.0	<0.10	13.9	35.0	8.13	5.6		14.6	36.0
	5						8.10	6.0		13.3	31.7	8.12	5.6		13.9	33.3	8.12	6.0		14.0	34.0	8.13	5.8		14.7	37.0
0.05	1	7.89	6.1	0.32	14.0	32.0	7.98	6.0		13.5	36.2	8.02	5.6		13.9	41.1	8.02	6.4		14.0	38.0	8.03	5.2	0.13	14.4	40.0
	2						8.03	6.2	0.17	14.5	34.0	8.11	5.6	0.12	15.0	35.4	8.13	6.4		15.2	38.0	8.15	5.6		15.2	40.0
	3						8.01	6.0		13.6	33.7	8.05	5.7		14.1	34.9	8.10	6.3		14.4	36.0	8.10	5.6		14.2	37.0
	4						8.02	6.0		13.3	34.5	8.04	5.8		13.7	36.9	8.07	6.3	<0.10	13.9	38.0	8.06	5.6		14.0	40.0
	5						8.01	6.0		13.3	34.5	8.04	5.6		13.8	36.5	8.05	6.3		14.0	38.0	8.06	5.6		14.0	40.0
0.1	1	7.96	6.0	0.56	14.0	32.2	8.02	6.1		13.3	35.0	8.03	5.4		13.7	37.8	8.04	6.2		13.9	40.0	8.06	5.8	0.12	13.9	40.0
	2						8.03	6.1	0.24	14.2	33.6	8.09	5.5	0.13	14.9	34.5	8.11	6.3		14.9	35.0	8.13	5.8		14.6	36.0
	3						8.02	6.0		13.8	34.2	8.05	5.7		14.2	36.1	8.06	6.3		14.4	38.0	8.08	5.8		14.3	40.0
	4						8.02	5.9		14.3	33.5	8.07	5.5		14.9	34.2	8.09	6.3	<0.10	15.0	35.0	8.11	5.8		14.7	36.0
	5						8.04	6.1		13.2	33.6	8.07	5.6		14.8	34.4	8.11	6.3		14.0	35.0	8.13	5.8		13.9	36.0
0.2	1	7.87	6.1	1.32	14.0	32.0	8.03	6.0		13.2	33.5	8.11	5.6		13.9	34.3	8.12	6.3		14.1	35.0	8.15	5.8	0.20	13.8	36.0
	2						8.02	6.0	0.53	13.2	33.6	8.10	5.7	0.20	13.9	34.6	8.12	6.3		14.1	35.0	8.14	5.8		13.7	37.0
	3						8.03	6.0		13.5	33.5	8.10	5.8		14.1	34.1	8.13	6.3		14.3	35.0	8.15	5.8		13.9	36.0
	4						8.01	6.0		13.5	33.7	8.09	5.8		14.0	34.8	8.12	6.3	0.22	14.3	36.0	8.14	5.8		13.9	37.0
	5						8.02	6.0		13.8	33.8	8.10	5.7		14.2	34.8	8.04	6.3		14.3	35.0	8.15	5.8		14.2	36.0
0.4	1	7.66	6.0	3.00	14.0	32.1	7.95	5.8		13.2	35.1	7.99	5.4		13.8	38.2	8.08	6.3		13.9	41.0	8.05	5.8	0.30	13.7	40.0
	2						7.97	5.8	0.86	13.2	34.5	8.06	5.3	0.32	13.9	36.3	8.10	6.3		14.1	38.0	8.08	5.8		13.7	41.0
	3						7.99	6.0		14.5	33.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.99	5.9		14.4	33.5	7.89	5.1		15.0	34.1	—	—	—	—	—	—	—	—	—	—
	5						7.99	5.9		14.4	33.6	8.04	5.4		14.8	34.5	8.13	6.3	0.23	14.9	35.0	8.15	5.8		15.2	36.0
0.8	1	7.35	6.0	6.34	14.0	32.0	7.88	5.4		13.5	35.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.93	5.7	1.95	14.1	33.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.91	5.7		13.9	33.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.93	5.7		13.9	33.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.92	5.8		14.2	33.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1.5	2	7.00	5.9	14.6	14.0	32.0	7.84	5.5		14.1	33.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.80	5.4	4.23	14.2	33.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.85	5.4		13.9	33.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.85	5.4		13.9	33.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3.0	1	6.81	5.7	28.5	14.0	32.0	7.89	5.7		13.9	33.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.86	5.9	9.65	13.8	33.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.88	5.9		13.6	33.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.81	5.8		13.0	34.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.81	5.8		12.9	34.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Min		6.81	5.7	0.02	14.0	32.0	7.80	5.4	0.17	12.9	30.9	7.89	5.1	0.12	13.6	31.7	8.02	6.0	<0.10	13.9	32.0	8.03	5.2	0.12	13.7	33.0
Max		8.02	6.2	28.50	14.0	32.2	8.11	6.2	9.65	14.5	36.2	8.13	5.8	0.32	15.0	41.1	8.13	6.4	0.23	15.2	41.0	8.15	6.1	0.30	15.2	41.0

Note: — = All animals dead.

APPENDIX TABLE 3

Citharichthys stigmaeus
SURVIVAL DATA FOR EFFLUENT TEST
HSW-1

Concentration (%)	Rep	Initial Added	Day 1	Day 2	Day 3	Day 4	% Survival	Average % Survival
Control	**1**	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	100.0
0.05	**1**	10	10	10	10	10	100	
	2	10	10	9	9	9	90	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	98.0
0.1	**1**	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	9	90	
	4	10	10	10	10	10	100	97.5
0.2	**1**	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	9	9	90	98.0
0.4	**1**	10	10	10	10	10	100	
	2	10	7	6	6	6	60	
	3	10	10	8	8	8	80	
	4	10	9	9	9	9	90	
	5	10	10	9	9	9	90	84.0
0.8	**1**	10	5	3	3	1	10	
	3	10	10	9	9	9	90	
	4	10	9	1	1	0	0	
	5	10	5	5	3	3	30	32.5
1.5	**1**	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0
30	**1**	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0

Notes: — = All animals dead.

APPENDIX TABLE 3 (Cont'd)

Citharichthys stigmaeus
SURVIVAL DATA FOR EFFLUENT TEST
HSW-2

Concentration (%)	Rep	Initial Added	Day 1	Day 2	Day 3	Day 4	% Survival	Average % Survival
Control	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	100.0
0.05	1	10	10	10	10	9	90	
	2	10	10	10	10	9	90	
	3	10	10	10	10	10	100	
	4	10	10	10	10	9	90	
	5	10	10	10	10	10	100	94.0
0.1	1	10	10	10	9	9	90	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	98.0
0.2	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	9	9	9	90	
	5	10	10	9	9	9	90	96.0
0.4	1	10	4	3	2	2	20	
	2	10	4	3	3	2	20	
	3	10	0	—	—	—	0	
	4	10	3	0	—	—	0	
	5	10	3	3	3	3	30	14.0
0.8	1	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0
1.5	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0
3	1	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0

Notes: — = All animals dead.

APPENDIX TABLE 4

Citharichthys stigmaeus
WATER QUALITY MEASUREMENTS FOR REFERENCE TOXICANT (S.D.S) TEST

Concentration (mg/L)	Rep	Day 0 pH	Day 0 DO	Day 0 °C	Day 0 Sal	Day 1 pH	Day 1 DO	Day 1 °C	Day 1 Sal
Control	**1**	8.02	5.8	15.9	32	7.20	5.7	15.2	31
	2					7.31	5.0	15.1	31
	3					7.31	4.7	15.1	31
1.6	**1**	8.03	5.8	15.9	32	7.49	4.7	15.1	31
	2					7.52	4.2	15.1	31
	3					7.51	4.1	15.2	31
3.1	**1**	8.03	5.8	15.9	32	7.49	4.0	15.1	31
	2					7.43	4.0	15.2	30
	3					7.51	3.9	15.1	31
6.25	**1**	8.03	5.8	15.9	32	7.49	4.1	15.1	31
	2					7.48	4.1	15.1	30
	3					7.47	4.0	15.1	31
12.5	**1**	8.04	5.8	15.9	32	7.40	3.9	15.1	31
	2					7.44	3.7	15.1	31
	3					7.51	3.7	15.1	31
25	**1**	8.03	5.7	15.9	32	7.44	3.0	15.1	31
	2					7.42	3.1	15.1	31
	3					7.36	3.2	15.0	31
Min		8.02	5.7	15.9	32	7.20	3.0	15.0	30
Max		8.04	5.8	15.9	32	7.52	5.7	15.2	31

APPENDIX TABLE 5

Citharichthys stigmaeus
SURVIVAL DATA
FOR REFERENCE TOXICANT (S.D.S.) TEST

Concentration (mg/L)	Rep	Initial Added	Day 1	% Survival	Average % Survival
Control	1	5	4	80	
	2	5	5	100	
	3	5	5	100	93.3
1.6	1	5	2	40	
	2	5	5	100	
	3	5	5	100	80.0
3.1	1	5	5	100	
	2	5	5	100	
	3	5	5	100	100.0
6.25	1	5	0	0	
	2	5	0	0	
	3	5	0	0	0.0
12.5	1	5	0	0	
	2	5	0	0	
	3	5	0	0	0.0
25	1	5	0	0	
	2	5	0	0	
	3	5	0	0	0.0

APPENDIX TABLE 6

Mysidopsis bahia
WATER QUALITY MEASUREMENTS FOR EFFLUENT TEST
HSW-1

Concentration		Day 0					Day 1					Day 2					Day 3					Day 4				
(%)	Rep	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal
Control	1	8.06	5.4		18.0	32.0	8.14	5.2	<0.01	19.6	32.0	8.11	5.1		19.8	33.0	8.11	4.6	<0.10	21.7	33.9	8.08	4.9	<0.10	21.1	34.1
	2						8.13	5.2		19.9	32.0	8.08	5.2		20.1	33.0	8.07	4.6		21.6	33.6	8.07	5.1		21.1	34.1
	3						8.16	5.1		19.7	32.0	8.12	5.4		20.2	33.6	8.11	4.5		21.6	34.7	8.09	5.1		21.1	34.0
	4						8.16	5.2		19.7	32.0	8.12	5.4		20.2	33.3	8.14	4.5		21.6	33.9	8.12	5.0		21.0	33.8
	5						8.15	5.2		19.7	32.0	8.11	5.5		20.2	33.1	8.11	4.5		21.5	34.0	8.10	4.9		21.0	34.1
0.05	1	8.08	5.4	0.13	18.0	32.0	8.14	5.2	0.12	19.8	32.0	8.13	5.4	0.14	20.1	33.6	8.13	4.5	0.13	21.7	34.8	8.12	5.0	0.13	20.9	34.1
	2						8.15	5.2		19.8	32.0	8.14	5.6		20.2	32.7	8.15	4.4		21.6	33.6	8.13	5.0		21.1	34.1
	3						8.13	5.2		19.6	32.0	8.11	5.6		20.2	32.8	8.13	4.5		21.6	33.6	8.14	5.1		21.1	34.3
	4						8.10	5.0		19.6	32.0	8.11	5.6		20.1	32.3	8.12	4.5		21.4	32.8	8.12	5.1		20.0	34.2
	5						8.04	5.1		19.5	32.0	8.08	5.5		20.1	32.4	8.06	4.5		21.3	33.3	8.10	5.0		20.0	34.0
0.1	1	8.06	5.4	0.25	18.0	32.0	8.02	5.0	0.19	19.6	32.0	8.09	5.4	0.29	20.2	33.1	8.06	4.6	0.23	21.7	33.9	8.12	5.0	0.24	21.0	35.1
	2						7.92	5.0		19.6	32.0	8.03	5.4		20.1	33.1	8.02	4.4		21.5	34.1	8.10	5.1		21.0	35.0
	3						7.99	4.9		19.5	32.0	8.10	5.3		19.9	33.0	8.13	4.4		21.3	35.0	8.13	4.9		20.9	35.1
	4						8.00	5.0		19.4	32.0	8.10	5.3		19.9	33.3	8.10	4.5		21.2	34.7	8.10	5.0		20.9	35.1
	5						8.02	5.0		19.3	32.0	8.10	5.3		19.9	33.5	8.16	4.6		21.1	35.4	8.09	5.0		20.9	35.7
0.2	1	8.04	5.2	0.61	18.0	32.0	7.91	5.0	0.38	19.6	32.0	8.11	5.4	0.38	20.0	32.6	8.14	4.8	0.41	21.5	34.2	8.18	4.9	0.52	21.0	34.8
	2						7.75	4.4		19.1	32.0	8.07	5.4		19.6	36.0	8.05	4.6		20.9	41.1	8.21	5.0		21.0	41.2
	3						7.58	3.8		19.0	32.0	8.04	5.5		19.5	35.2	8.04	4.5		20.7	38.7	8.20	5.0		21.1	38.7
	4						7.76	4.2		18.9	32.0	8.06	5.5		19.6	35.6	8.05	4.5		20.9	38.3	8.17	5.1		21.0	38.9
	5						7.81	4.4		19.0	32.0	8.07	5.4		19.5	35.0	8.11	4.5		20.9	35.9	8.17	5.1		21.0	36.2
0.4	1	8.02	5.2	1.17	18.0	32.0	7.83	4.2	0.71	19.5	32.0	8.16	5.4	0.74	19.9	32.9	8.20	4.6	0.82	21.4	34.0	8.21	5.1	1.09	20.9	34.8
	2						7.87	4.6		19.5	32.0	8.18	5.4		19.9	32.9	8.20	4.6		21.0	33.7	8.18	5.2		20.9	34.0
	3						7.73	3.8		19.5	32.0	8.19	5.2		19.9	33.0	8.20	4.6		21.2	33.8	8.19	5.1		20.9	33.9
	4						7.79	4.8		19.4	32.0	8.17	5.1		19.9	32.9	8.15	4.5		21.2	33.5	8.21	5.1		20.8	33.9
	5						7.91	4.4		19.4	32.0	8.19	5.1		19.9	33.0	8.20	4.5		21.0	33.6	8.21	5.1		20.8	33.9
0.8	1	7.92	5.3	3.62	19.9	32.0	7.62	3.8	1.52	19.5	32.0	8.22	5.3	1.38	19.9	33.2	8.23	4.6	1.42	21.3	33.9	8.22	5.1	1.53	21.0	34.1
	2						7.70	3.4		19.5	32.0	8.21	5.2		19.9	32.4	8.21	4.5		21.2	33.5	8.22	5.0		21.1	34.2
	3						7.61	3.4		19.4	32.0	8.19	5.1		19.9	33.2	8.19	4.4		21.1	34.0	8.21	5.0		21.0	34.7
	4						7.82	3.8		19.4	32.0	8.22	5.0		19.9	32.9	8.23	4.4		21.2	34.0	8.27	5.1		21.0	34.7
	5						7.59	3.0		19.4	32.0	8.24	5.0		19.9	33.0	8.23	4.4		21.2	34.0	8.24	5.0		21.0	34.2
1.6	1	7.88	5.2	7.14	20.2	32.0	7.61	1.4	3.27	19.6	32.0	8.25	5.2	3.45	20.1	32.7	8.23	4.6	3.27	21.3	33.8	8.28	4.9	3.12	21.1	34.1
	2						7.67	1.8		19.4	32.0	8.25	5.1		19.9	32.9	8.22	4.5		21.1	33.7	8.24	4.9		21.1	34.2
	3						7.68	1.8		18.6	32.0	8.15	5.0		19.5	34.4	—	—	—	—	—	—	—	—	—	—
	4						7.51	0.4		19.1	32.0	8.24	5.0		19.6	32.4	—	—	—	—	—	—	—	—	—	—
	5						7.70	2.4		18.9	32.0	8.19	5.0		19.4	36.1	8.12	4.5		20.6	40.8	8.31	5.0		20.9	33.9
Min		7.88	5.2	0.13	18.0	32.0	7.51	0.4	<0.01	18.6	32.0	8.03	5.0	0.14	19.4	32.3	8.02	4.4	<0.10	20.6	32.8	8.07	4.9	<0.10	20.0	33.8
Max		8.08	5.4	7.14	20.2	32.0	8.16	5.2	3.27	19.9	32.0	8.25	5.6	3.45	20.2	36.1	8.23	4.8	3.27	21.7	41.1	8.31	5.2	3.12	21.1	41.2

Note: — = All animals dead.

APPENDIX TABLE 6 (Cont'd)

Mysidopsis bahia
WATER QUALITY MEASUREMENTS FOR EFFLUENT TEST
HSW-2

Concentration				Day 0					Day 1					Day 2					Day 3					Day 4		
(%)	Rep	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal
Control	1	8.06	5.4		18.0	32.0	8.14	5.2	<0.01	19.6	32.0	8.11	5.1		19.8	33.0	8.11	4.6	<0.10	21.7	33.9	8.08	4.9	<0.10	21.1	34.1
	2						8.13	5.2		19.9	32.0	8.08	5.2		20.1	33.0	8.07	4.6		21.6	33.6	8.07	5.1		21.1	34.1
	3						8.16	5.1		19.7	32.0	8.12	5.4		20.2	33.6	8.11	4.5		21.6	34.7	8.09	5.1		21.1	34.0
	4						8.16	5.2		19.7	32.0	8.12	5.4		20.2	33.3	8.14	4.5		21.6	33.9	8.12	5.0		21.0	33.8
	5						8.15	5.2		19.7	32.0	8.11	5.5		20.2	33.1	8.11	4.5		21.5	34.0	8.10	4.9		21.0	34.1
0.05	1	8.04	5.2	0.13	19.9	32.0	8.00	5.0	0.11	19.2	32.0	8.11	4.9	0.12	19.9	32.7	8.12	4.6	0.12	21.1	33.6	8.18	5.0	0.11	21.0	34.1
	2						7.97	4.8		19.1	32.0	8.09	4.9		19.6	33.0	8.08	4.5		20.9	33.7	8.19	5.1		21.1	34.2
	3						7.96	4.8		18.9	32.0	8.07	4.8		19.4	34.0	8.06	4.4		20.6	34.7	8.22	5.1		21.1	34.1
	4						7.96	4.8		18.6	32.0	8.08	4.8		19.2	34.2	8.05	4.4		20.4	35.8	8.21	5.1		21.1	34.1
	5						8.03	4.9		18.6	32.0	8.09	4.8		19.3	34.4	8.04	4.5		20.4	36.6	8.19	5.0		21.0	34.2
0.1	1	8.05	5.2	0.25	19.6	32.0	8.00	5.0	0.18	19.1	32.0	8.12	4.9	0.16	19.6	34.7	8.15	4.4	0.17	20.9	36.0	8.19	5.0	0.17	21.0	36.3
	2						7.97	5.0		19.1	32.0	8.15	5.0		19.6	34.6	8.15	4.5		20.7	33.7	8.20	5.0		21.1	36.4
	3						8.01	5.0		18.9	32.0	8.15	4.9		19.4	35.4	8.15	4.6		20.5	34.7	8.16	5.0		21.1	34.7
	4						7.97	4.9		18.8	32.0	8.15	4.9		19.4	35.2	8.14	4.4		20.3	36.0	8.17	5.0		21.1	35.2
	5						8.07	4.9		18.7	32.0	8.17	5.0		19.3	34.6	8.18	4.4		20.2	39.0	8.19	5.0		21.1	39.7
0.2	1	7.96	5.2	0.61	20.1	32.0	7.74	4.4	0.57	19.0	32.0	8.16	5.0	0.30	18.7	31.8	8.14	4.4	0.32	19.4	32.5	8.21	5.0	0.39	21.1	33.4
	2						7.78	4.6		19.1	32.0	8.15	4.9		18.7	32.5	8.13	4.5		19.4	32.8	8.09	5.1		21.0	34.2
	3						7.81	4.5		18.9	32.0	8.14	5.0		18.6	32.4	8.15	4.4		19.2	32.9	8.21	4.9		21.0	34.1
	4						7.85	4.6		18.8	32.0	8.16	5.0		18.4	32.4	8.16	4.4		19.1	33.7	8.23	4.9		21.0	34.1
	5						7.81	4.6		18.6	32.0	8.15	5.0		18.4	33.7	8.15	4.5		19.1	35.1	8.16	5.1		21.1	34.2
0.4	1	7.92	5.2	1.17	20.2	32.0	7.76	3.6	1.08	19.1	31.0	8.15	5.0	1.10	18.9	31.5	8.19	4.6	1.20	19.5	32.4	8.23	5.1	1.16	21.1	33.7
	2						7.75	3.6		19.1	32.0	8.16	5.0		18.6	33.9	8.14	4.5		19.5	35.9	8.18	5.1		21.1	36.2
	3						7.59	1.8		18.7	32.0	8.14	5.0		18.4	34.1	8.10	4.4		19.2	36.5	8.19	5.1		21.1	37.0
	4						7.73	3.4		18.6	32.0	8.16	5.0		18.4	33.7	8.14	4.3		19.2	35.1	8.19	5.0		21.1	36.1
	5						7.80	3.6		18.6	32.0	8.16	5.0		18.5	33.8	8.16	4.3		19.2	35.6	8.22	5.0		21.1	36.1
0.8	1	7.79	5.2	3.62	20.2	32.0	7.52	1.2	2.17	19.0	32.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.61	1.8		19.0	32.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.54	2.2		18.9	32.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.71	2.2		18.9	32.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.66	2.6		18.9	32.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1.6	1	7.67	5.0	7.14	20.0	32.0	7.58	2.8	4.43	19.0	32.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.39	2.6		18.9	32.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.46	1.4		18.9	32.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.38	1.6		18.9	32.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.49	1.6		18.9	32.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Min		7.67	5.0	0.13	18.0	32.0	7.38	1.2	<0.01	18.6	31.0	8.07	4.8	0.12	18.4	31.5	8.04	4.3	<0.10	19.1	32.4	8.07	4.9	<0.10	21.0	33.4
Max		8.06	5.4	7.14	20.2	32.0	8.16	5.2	4.43	19.9	32.0	8.17	5.5	1.10	20.2	35.4	8.19	4.6	1.20	21.7	39.0	8.23	5.1	1.16	21.1	39.7

Note: — = All animals dead.

APPENDIX TABLE 7

Mysidopsis bahia
SURVIVAL DATA FOR EFFLUENT TEST
HSW-1

Concentration (%)	Rep	Initial Added	Day 1	Day 2	Day 3	Day 4	% Survival	Average % Survival
Control	**1**	10	10	10	9	10	100	
	2	10	10	10	10	9	90	
	3	10	10	10	9	9	90	
	4	10	10	10	10	9	90	
	5	10	10	10	10	9	90	92.0
0.05	**1**	10	9	9	9	9	90	
	2	10	10	10	9	8	80	
	3	10	10	8	8	7	70	
	4	10	9	7	7	6	60	
	5	10	10	9	8	9	90	78.0
0.1	**1**	10	6	5	2	6	60	
	2	10	10	9	5	8	80	
	3	10	8	8	7	6	60	
	4	10	8	6	7	8	80	
	5	10	9	8	8	6	60	68.0
0.2	**1**	10	9	8	4	7	70	
	2	10	8	7	5	7	70	
	3	10	9	7	7	8	80	
	4	10	9	8	7	8	80	
	5	10	10	9	8	8	80	76.0
0.4	**1**	10	8	7	5	6	60	
	2	10	8	7	6	6	60	
	3	10	8	8	6	6	60	
	4	10	8	7	7	8	80	
	5	10	10	9	8	7	70	66.0
0.8	**1**	10	5	*	*	3	30	
	2	10	4	*	*	3	30	
	3	10	6	*	*	3	30	
	4	10	4	*	*	3	30	
	5	10	3	*	*	0	0	24.0
1.6	**1**	10	3	*	*	0	0	
	2	10	2	*	*	0	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	1	*	*	0	0	0.0

Notes: — = All animals dead.
* Sample too turbid to do counts.

APPENDIX TABLE 7 (Cont'd)

Mysidopsis bahia
SURVIVAL DATA FOR EFFLUENT TEST
HSW-2

Concentration (%)	Rep	Initial Added	Day 1	Day 2	Day 3	Day 4	% Survival	Average % Survival
Control	1	10	10	10	9	10	100	
	2	10	10	10	10	9	90	
	3	10	10	10	9	9	90	
	4	10	10	10	10	9	90	
	5	10	10	10	10	9	90	92.0
0.05	1	10	10	10	10	9	90	
	2	10	9	9	8	6	60	
	3	10	10	9	8	7	70	
	4	10	8	8	8	5	50	
	5	10	9	8	8	6	60	66.0
0.1	1	10	7	7	7	6	60	
	2	10	8	7	5	4	40	
	3	10	7	6	4	7	70	
	4	10	8	7	4	4	40	
	5	10	7	7	6	3	30	48.0
0.2	1	10	6	4	2	2	20	
	2	10	5	5	4	2	20	
	3	10	6	6	3	5	50	
	4	10	6	6	4	6	60	
	5	10	5	4	2	4	40	38.0
0.4	1	10	5	*	*	1	10	
	2	10	3	*	*	2	20	
	3	10	4	*	*	1	10	
	4	10	3	*	*	0	0	
	5	10	3	*	*	0	0	8.0
0.8	1	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0
1.6	1	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0

Notes: — = All animals dead.
* Sample too turbid to do counts.

APPENDIX TABLE 8

Mysidopsis bahia
WATER QUALITY MEASUREMENTS
FOR REFERENCE TOXICANT (S.D.S) TEST

Concentration		Day 0				Day 1				Day 2				Day 3				Day 4			
(mg/L)	Rep	pH	DO	°C	Sal	pH	DO	°C	Sal	pH	DO	°C	Sal	pH	DO	°C	Sal	pH	DO	°C	Sal
Control	1	8.03	5.6	20.9	32.0	8.00	4.8	21.2	32.0	7.67	5.4	21.6	33.0	7.90	3.8	21.6	33.9	7.93	4.1	21.1	34.0
	2					8.02	4.8	21.2	32.0	7.72	5.4	21.5	33.0	7.91	3.7	21.6	30.9	7.94	4.0	21.1	34.1
	3					8.03	4.8	21.3	32.0	7.70	5.3	21.6	33.0	7.90	3.8	21.8	33.8	7.94	4.0	21.1	34.2
1.25	1	8.04	5.4	20.9	32.0	8.00	4.8	21.3	32.0	7.58	5.2	21.6	33.0	7.90	3.6	21.8	33.8	7.94	4.0	20.9	34.1
	2					8.02	4.8	21.2	32.0	7.54	5.1	21.6	33.0	7.93	3.5	21.8	33.7	7.93	4.0	21.0	34.3
	3					8.03	4.8	21.2	32.0	7.38	5.1	21.6	33.0	7.95	3.5	21.7	33.8	7.95	3.9	21.0	34.7
2.5	1	8.04	5.4	20.9	32.0	8.01	4.8	21.3	32.0	7.62	5.1	21.6	33.0	7.96	3.6	21.8	33.8	7.99	3.9	20.9	34.1
	2					8.02	4.8	21.1	32.0	7.42	5.1	21.6	33.0	7.93	3.6	21.8	33.6	7.92	3.8	20.9	34.0
	3					8.02	4.6	21.1	32.0	7.47	5.0	21.6	33.0	7.93	3.6	21.7	33.9	7.91	3.8	21.0	33.9
5	1	8.04	5.4	21.1	32.0	8.00	4.8	21.1	32.0	7.32	4.7	21.6	33.0	7.98	3.7	21.8	33.1	7.92	3.8	21.0	33.8
	2					8.00	4.7	21.1	32.0	7.38	4.8	21.6	33.0	7.92	3.5	21.8	33.0	7.92	3.9	21.0	33.7
	3					7.98	4.7	21.1	32.0	7.31	4.6	21.5	33.0	7.92	3.5	21.8	33.9	7.91	3.9	21.0	33.9
10	1	8.03	5.4	21.2	32.0	7.91	4.6	21.2	32.0	7.30	4.1	21.5	33.0	7.86	3.6	21.9	33.7	7.89	3.9	20.9	34.0
	2					7.91	4.5	21.2	32.0	7.31	4.2	21.5	33.0	7.88	3.6	21.9	33.8	7.89	3.9	20.9	33.9
	3					7.91	4.3	21.2	32.0	7.31	4.2	21.6	33.0	7.87	3.6	22.0	33.6	7.91	3.9	21.0	34.1
20	1	8.02	5.3	20.8	32.0	7.85	4.4	20.9	32.0	7.20	4.0	21.6	33.0	7.78	3.7	21.8	33.4	7.90	3.9	21.0	33.9
	2					7.85	4.4	20.9	32.0	7.21	4.0	21.6	33.0	7.75	3.8	21.8	33.4	7.88	3.8	21.0	33.4
	3					7.86	4.2	20.9	32.0	7.21	4.0	21.5	33.0	7.78	3.8	21.8	33.2	7.88	3.9	21.0	33.9
Min		8.02	5.3	20.8	32.0	7.85	4.2	20.9	32.0	7.20	4.0	21.5	33.0	7.75	3.5	21.6	30.9	7.88	3.8	20.9	33.4
Max		8.04	5.6	21.2	32.0	8.03	4.8	21.3	32.0	7.72	5.4	21.6	33.0	7.98	3.8	22.0	33.9	7.99	4.1	21.1	34.7

APPENDIX TABLE 9

Mysidopsis bahia
SURVIVAL DATA FOR REFERENCE TOXICANT (S.D.S.) TEST

Concentration (mg/L)	Rep	Initial Added	Day 1	Day 2	Day 3	Day 4	% Survival	Average % Survival
Control	**1**	10	10	10	9	9	90	
	2	10	10	10	10	9	90	
	3	10	10	10	9	9	90	90.0
1.25	**1**	10	9	9	8	7	70	
	2	10	10	9	6	6	60	
	3	10	9	8	8	8	80	70.0
2.5	**1**	10	9	8	6	5	50	
	2	10	10	8	6	6	60	
	3	10	10	8	6	6	60	56.7
5	**1**	10	11	9	5	5	50	
	2	10	9	7	5	4	40	
	3	10	10	9	7	5	50	46.7
10	**1**	10	10	9	7	5	50	
	2	10	9	9	4	4	40	
	3	10	9	7	5	5	50	46.7
20	**1**	10	7	5	3	2	20	
	2	10	10	8	7	5	50	
	3	10	10	8	5	4	40	36.7

APPENDIX TABLE 10

Strongylocentrotus purpuratus

WATER QUALITY MEASUREMENTS FOR THE EFFLUENT TEST

Test Dates: 4/7-4/11/94

Site	Concentration (%)	Day 0 °C	Day 0 DO	Day 0 pH	Day 0 Sal	Day 1 °C	Day 1 DO	Day 1 pH	Day 1 Sal	Day 2 °C	Day 2 DO	Day 2 pH	Day 2 Sal	Day 3 °C	Day 3 DO	Day 3 pH	Day 3 Sal	Day 4 °C	Day 4 DO	Day 4 pH	Day 4 Sal
Control		16.3	8.0	7.49	26	15.1	8.7	7.77	27	16.2	8.4	7.87	26	15.4	8.4	7.79	26	15.7	8.2	7.89	27
HSW-1	**0.08**	16.0	8.1	7.42	26	14.5	8.6	7.62	27	15.6	8.4	7.86	26	15.6	7.7	7.84	26	15.9	8.1	7.88	26
	0.15	16.0	8.0	7.43	27	14.5	6.6	7.51	27	15.5	7.4	7.80	27	15.6	6.5	7.80	27	15.7	8.1	7.85	27
	0.3	16.2	8.0	7.83	29	14.5	4.5	7.54	29	15.7	2.2	7.59	28	15.5	3.0	7.47	28	15.8	7.8	7.65	29
	0.6	16.2	8.0	7.51	26	14.5	4.1	7.51	27	15.9	2.3	7.56	26	15.6	2.7	7.49	26	15.7	7.4	7.93	27
	1.2	16.4	8.0	7.62	26	14.5	1.5	7.10	29	15.6	1.3	7.46	28	15.7	1.7	7.51	27	15.1	7.4	7.97	29
HSW-2	**0.08**	16.2	8.0	7.33	26	14.5	1.2	7.41	27	15.3	7.7	7.93	27	15.6	7.9	7.80	27	15.2	7.6	7.95	27
	0.15	16.4	8.0	7.34	27	14.5	1.6	7.42	27	15.5	7.7	7.96	27	15.7	7.3	7.77	27	15.0	7.8	7.95	27
	0.3	16.4	8.0	7.21	27	14.5	1.3	7.45	27	15.6	7.8	7.82	27	15.6	6.9	7.79	27	15.0	7.8	7.97	27
	0.6	16.0	8.0	7.21	26	15.7	1.3	7.42	27	16.2	3.0	7.52	27	15.7	2.7	7.47	27	16.2	6.6	7.71	27
	1.2	16.2	7.9	6.87	26	15.7	1.3	7.10	27	16.1	1.4	7.42	27	15.7	1.7	7.38	27	16.2	6.4	7.63	27
	Min	16.0	7.9	6.87	26	14.5	1.2	7.10	27	15.3	1.3	7.42	26	15.4	1.7	7.38	26	15.0	6.4	7.63	26
	Max	16.4	8.1	7.83	29	15.7	8.7	7.77	29	16.2	8.4	7.96	28	15.7	8.4	7.84	28	16.2	8.2	7.97	29

APPENDIX TABLE 11

Strongylocentrotus purpuratus

SUMMARY OF SURVIVAL AND DEVELOPMENT FOR THE ECHINODERM LARVAE

EFFLUENT TEST

Test Dates: 4/7-4/11/94

Concentration (%)	Rep	Total Normal	Total Abnormal	Total Larvae/mL	% Survival	% Abnormal	Treatment Mortality (%)
Initial Counts	1	156		31.2			
	2	136		27.2			
	3	141		28.2			
	4	168		33.6			
	5	137		27.4			
	Mean			29.5			
Final Control	1	95	14	21.8		12.8	
	2	59	4	12.6		6.3	
	3	109	7	23.2		6.0	
	4	94	1	19.0		1.1	
	5	90	2	18.4		2.2	
	Mean			19.0	64.4	5.7	NA
HSW-1							
0.08	1	45	32	15.4		41.6	
	2	63	53	23.2		45.7	
	3	66	43	21.8		39.4	
	4	76	38	22.8		33.3	
	5	78	40	23.6		33.9	
	Mean			21.4	72.4	38.8	0.0
0.15	1	0	79	15.8		100.0	
	2	0	48	9.6		100.0	
	3	0	44	8.8		100.0	
	4	0	89	17.8		100.0	
	5	0	99	19.8		100.0	
	Mean			14.4	48.7	100.0	24.4
0.3	1	0	50	10.0		100.0	
	2	0	53	10.6		100.0	
	3	0	57	11.4		100.0	
	4	0	84	16.8		100.0	
	5	0	58	11.6		100.0	
	Mean			12.1	40.9	100.0	36.4
0.6	1	0	66	13.2		100.0	
	2	0	85	17.0		100.0	
	3	0	74	14.8		100.0	
	4	0	112	22.4		100.0	
	5	0	57	11.4		100.0	
	Mean			15.8	53.4	100.0	17.1
1.2	1	0	106	21.2		100.0	
	2	0	115	23.0		100.0	
	3	0	92	18.4		100.0	
	4	0	60	12.0		100.0	
	5	0	114	22.8		100.0	
	Mean			19.5	66.0	100.0	100.0

APPENDIX TABLE 11 (Cont'd)

Strongylocentrotus purpuratus

SUMMARY OF SURVIVAL AND DEVELOPMENT FOR THE ECHINODERM LARVAE

EFFLUENT TEST

Test Dates: 4/7-4/11/94

Concentration (%)	Rep	Total Normal	Total Abnormal	Total Larvae/mL	% Survival	% Abnormal	Treatment Mortality (%)
HSW-2							
0.08	1	0	63	12.6		100.0	
	2	0	61	12.2		100.0	
	3	0	39	7.8		100.0	
	4	0	36	7.2		100.0	
	5	0	58	11.6		100.0	
	Mean			10.3	34.8	100.0	45.9
0.15	1	0	101	20.2		100.0	
	2	0	112	22.4		100.0	
	3	0	129	25.8		100.0	
	4	0	122	24.4		100.0	
	5	0	130	26.0		100.0	
	Mean			23.8	80.5	100.0	0.0
0.3	1	0	89	17.8		100.0	
	2	0	128	25.6		100.0	
	3	0	119	23.8		100.0	
	4	0	119	23.8		100.0	
	5	0	91	18.2		100.0	
	Mean			21.8	74.0	100.0	0.0
0.6	1	0	116	23.2		100.0	
	2	0	119	23.8		100.0	
	3	0	113	22.6		100.0	
	4	0	79	15.8		100.0	
	5	0	104	20.8		100.0	
	Mean			21.2	72.0	100.0	0.0
1.2	1	0	76	15.2		100.0	
	2	0	87	17.4		100.0	
	3	0	92	18.4		100.0	
	4	0	88	17.6		100.0	
	5	0	76	15.2		100.0	
	Mean			16.8	56.8	100.0	11.8

APPENDIX TABLE 12

Strongylocentrotus purpuratus
WATER QUALITY MEASUREMENTS FOR THE REFERENCE TOXICANT (COPPER) TEST
Test Dates: 4/7-4/11/94

Concentration	Day 0				Day 1				Day 2				Day 3				Day 4			
(µg/L)	°C	DO	pH	Sal	°C	DO	pH	Sal	°C	DO	pH	Sal	°C	DO	pH	Sal	°C	DO	pH	Sal
0.1	15.6	8.9	7.88	29	14.3	NT	NT	NT	14.2	8.1	7.97	29	14.4	8.4	8.01	29	15.0	7.6	7.98	29
0.32	15.8	8.9	7.90	29	14.3	NT	NT	NT	14.2	8.1	8.00	29	14.4	8.4	8.04	29	15.0	7.7	7.99	29
1.8	15.8	8.9	7.92	29	14.4	NT	NT	NT	14.3	8.3	8.02	29	14.5	8.3	8.06	29	14.9	7.9	8.00	29
18	15.8	9.1	7.80	28	14.3	NT	NT	NT	14.2	8.3	8.01	28	14.5	8.3	8.06	29	15.0	7.9	8.00	29
56	15.8	9.1	7.86	26	14.4	NT	NT	NT	14.2	8.6	8.02	25	14.5	8.3	8.06	29	15.0	8.0	8.01	25
Min	15.6	8.9	7.80	26	14.3				14.2	8.1	7.97	25	14.4	8.3	8.01	29	14.9	7.6	7.98	25
Max	15.8	9.1	7.92	29	14.4				14.3	8.6	8.02	29	14.5	8.4	8.06	29	15.0	8.0	8.01	29

Note: NT = Not taken.

APPENDIX TABLE 13

Strongylocentrotus purpuratus
SUMMARY OF SURVIVAL AND DEVELOPMENT FOR THE ECHINODERM LARVAE
REFERENCE TOXICANT (Copper) TEST
Test Dates: 4/7-4/11/94

Concentration (μg/L)	Rep	Total Normal	Total Abnormal	Total Larvae/mL	% Survival	% Abnormal	Treatment Mortality (%)
Copper							
0.1	1	78	14	18.4		15.2	
	2	86	19	21.0		18.1	
	3	86	12	19.6		12.2	
	Mean			19.7	66.7	15.2	0.0
0.32	1	26	1	5.4		3.7	
	2	33	1	6.8		2.9	
	3	96	0	19.2		0.0	
	Mean			10.5	35.5	2.2	44.9
1.8	1	69	4	14.6		5.5	
	2	60	2	12.4		3.2	
	3	96	4	20.0		4.0	
	Mean			15.7	53.1	4.2	17.5
18	1	3	51	10.8		94.4	
	2	0	31	6.2		100.0	
	3	0	28	5.6		100.0	
	Mean			7.5	25.5	98.1	60.4
56	1	0	38	7.6		100.0	
	2	0	24	4.8		100.0	
	3	0	48	9.6		100.0	
	Mean			7.3	24.9	100.0	61.4

APPENDIX TABLE 14

Mytilus edulis

WATER QUALITY MEASUREMENTS FOR THE EFFLUENT TEST

Test Dates: 4/7-4/9/94

Concentration (%)	Rep	Day 0 °C	Day 0 DO	Day 0 pH	Day 0 Sal	Day 1 °C	Day 2 °C	Day 2 DO	Day 2 pH	Day 2 Sal
Control	1	16.3	8.0	7.49	26	14.8	16.0	7.2	7.79	26
	2					14.6	16.0	7.2	7.82	26
	3					14.5	16.0	7.5	7.82	26
	4					14.7	16.0	7.5	7.88	26
	5					14.8	16.0	7.6	7.96	26
HSW-1										
0.08	1	16.0	8.1	7.42	26	14.5	16.0	7.6	7.68	26
	2					14.5	16.0	7.5	7.65	26
	3					14.4	16.1	7.3	7.67	26
	4					14.5	16.0	7.2	7.66	26
	5					14.5	16.1	7.1	7.66	26
0.15	1	16.0	8.0	7.43	27	14.5	16.0	4.0	7.46	26
	2					14.4	16.0	4.0	7.40	26
	3					14.4	16.0	3.8	7.38	26
	4					14.4	16.0	3.8	7.38	26
	5					14.5	16.0	3.6	7.40	26
0.3	1	16.2	8.0	7.83	29	14.4	16.0	2.0	7.44	28
	2					14.5	16.0	2.0	7.52	28
	3					14.5	16.0	1.8	7.54	28
	4					14.4	16.0	1.8	7.56	28
	5					14.5	16.0	1.5	7.55	28
0.6	1	16.2	8.0	7.51	26	14.5	16.0	1.6	7.56	26
	2					14.5	16.0	1.7	7.58	26
	3					14.5	16.0	1.7	7.60	26
	4					14.6	16.1	2.1	7.61	26
	5					14.5	16.1	2.0	7.60	26
1.2	1	16.4	8.0	7.62	26	14.4	16.0	4.2	7.62	26
	2					14.5	16.0	4.4	7.67	26
	3					14.5	16.0	4.3	7.64	26
	4					14.5	16.1	4.5	7.67	26
	5					14.5	16.1	4.6	7.83	26
	Min	16.0	8.0	7.42	26	14.4	16.0	1.5	7.38	26
	Max	16.4	8.1	7.83	29	14.8	16.1	7.6	7.96	28

APPENDIX TABLE 14 (Cont'd)

Mytilus edulis

WATER QUALITY MEASUREMENTS FOR THE EFFLUENT TEST

Test Dates: 4/7-4/9/94

Concentration (%)	Rep	Day 0 °C	Day 0 DO	Day 0 pH	Day 0 Sal	Day 1 °C	Day 2 °C	Day 2 DO	Day 2 pH	Day 2 Sal
HSW-2										
0.08	1	16.2	8.0	7.33	26	14.5	16.0	7.4	7.93	26
	2					14.6	16.0	7.7	7.92	26
	3					14.5	16.0	7.5	7.95	26
	4					14.5	16.1	7.5	7.97	26
	5					14.5	16.1	7.6	7.98	27
0.15	1	16.4	8.0	7.34	27	14.5	16.0	7.8	7.91	26
	2					14.5	16.0	8.0	7.94	26
	3					14.4	16.1	8.0	7.94	26
	4					14.5	16.1	7.9	7.86	26
	5					14.5	16.1	7.7	7.85	26
0.3	1	16.4	8.0	7.21	27	14.5	16.0	7.7	7.83	26
	2					14.5	16.0	7.7	7.86	26
	3					14.5	16.0	7.7	7.77	26
	4					14.5	16.1	7.6	7.59	26
	5					14.5	16.1	7.2	7.62	26
0.6	1	16.0	8.0	7.21	26	14.5	16.0	1.7	7.56	26
	2					14.6	16.1	1.7	7.53	26
	3					14.5	16.1	1.8	7.51	26
	4					14.6	16.1	1.8	7.51	26
	5					14.5	16.1	1.8	7.50	26
1.2	1	16.2	7.9	6.87	26	14.5	16.0	2.0	7.47	26
	2					14.5	16.1	1.7	7.37	26
	3					14.5	16.1	1.6	7.39	26
	4					14.5	16.1	2.0	7.42	26
	5					14.5	16.1	2.0	7.45	26
	Min	16.0	7.9	6.87	26	14.4	16.0	1.6	7.37	26
	Max	16.4	8.0	7.34	27	14.6	16.1	8.0	7.98	27

APPENDIX TABLE 15

Mytilus edulis
SUMMARY OF RESULTS FOR BIVALVE LARVAE BIOASSAY
Test Dates: 4/7-4/9/94

Concentration (%)	Rep	Total Normal	Total Abnormal	Total Larvae/mL	% Survival	% Abnormal	Treatment Mortality (%)
Initial Counts	1	129		25.8			
	2	95		19.0			
	3	102		20.4			
	4	76		15.2			
	5	115		23.0			
	Mean			20.7			
Final Control	1	103	13	23.2		11.2	
	2	97	3	20.0		3.0	
	3	86	5	18.2		5.5	
	4	83	5	17.6		5.7	
	5	106	7	22.6		6.2	
	Mean			20.3	98.2	6.3	NA
HSW-1							
0.08	1	22	61	16.6		73.5	
	2	2	78	16.0		97.5	
	3	0	72	14.4		100.0	
	4	0	77	15.4		100.0	
	5	5	67	14.4		93.1	
	Mean			15.4	74.2	92.8	24.3
0.15	1	0	74	14.8		100.0	
	2	0	76	15.2		100.0	
	3	0	64	12.8		100.0	
	4	0	86	17.2		100.0	
	5	0	61	12.2		100.0	
	Mean			14.4	69.8	100.0	28.9
0.3	1	0	139	27.8		100.0	
	2	0	120	24.0		100.0	
	3	0	133	26.6		100.0	
	4	0	91	18.2		100.0	
	5	0	82	16.4		100.0	
	Mean			22.6	100.0	100.0	0.0
0.6	1	0	73	14.6		100.0	
	2	0	133	26.6		100.0	
	3	0	90	18.0		100.0	
	4	0	96	19.2		100.0	
	5	0	93	18.6		100.0	
	Mean			19.4	93.7	100.0	4.4
1.2	1	0	90	18.0		100.0	
	2	0	75	15.0		100.0	
	3	0	87	17.4		100.0	
	4	0	80	16.0		100.0	
	5	0	91	18.2		100.0	
	Mean			16.9	81.7		16.7

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APPENDIX TABLE 15 (Cont'd)

Mytilus edulis
SUMMARY OF RESULTS FOR BIVALVE LARVAE BIOASSAY
Test Dates: 4/7-4/9/94

Concentration (%)	Rep	Total Normal	Total Abnormal	Total Larvae/mL	% Survival	% Abnormal	Treatment Mortality (%)
HSW-2							
0.08	1	0	109	21.8		100.0	
	2	1	84	17.0		98.8	
	3	0	100	20.0		100.0	
	4	0	110	22.0		100.0	
	5	0	95	19.0		100.0	
	Mean			20.0	96.4	99.8	1.7
0.15	1	0	100	20.0		100.0	
	2	0	90	18.0		100.0	
	3	0	111	22.2		100.0	
	4	0	89	17.8		100.0	
	5	0	115	23.0		100.0	
	Mean			20.2	97.6	100.0	0.5
0.3	1	0	82	16.4		100.0	
	2	0	101	20.2		100.0	
	3	0	97	19.4		100.0	
	4	0	89	17.8		100.0	
	5	0	104	20.8		100.0	
	Mean			18.9	91.4	100.0	6.8
0.6	1	0	144	28.8		100.0	
	2	0	128	25.6		100.0	
	3	0	94	18.8		100.0	
	4	0	103	20.6		100.0	
	5	0	119	23.8		100.0	
	Mean			23.5	100.0	100.0	0.0
1.2	1	0	81	16.2		100.0	
	2	0	94	18.8		100.0	
	3	0	104	20.8		100.0	
	4	0	88	17.6		100.0	
	5	0	87	17.4		100.0	
	Mean			18.2	87.7	100.0	10.5

APPENDIX TABLE 16

Mytilus edulis
WATER QUALITY MEASUREMENTS
FOR THE REFERENCE TOXICANT (C0PPER) TEST
Test Dates: 4/7-4/9/94

Concentration		Day 0				Day 1	Day 2			
µg/L	Rep	°C	DO	pH	Sal	°C	°C	DO	pH	Sal
0.56	1	15.8	9.2	7.91	30	14.3	14.0	7.7	7.95	28
	2					14.3	14.0	7.8	7.96	29
	3					14.3	14.0	7.9	7.96	29
3.2	1	15.7	8.9	7.91	29	14.3	14.1	7.9	7.96	28
	2					14.3	14.0	7.9	7.96	29
	3					14.2	14.0	8.1	7.96	29
10	1	15.6	8.7	7.92	29	14.3	14.0	8.0	7.96	28
	2					14.4	14.1	8.0	7.97	28
	3					14.3	14.1	8.1	7.97	28
32	1	15.6	9.7	7.78	26	14.3	14.0	8.0	7.97	26
	2					14.3	14.1	8.1	7.96	26
	3					14.3	14.1	8.1	7.95	26
56	1	15.8	9.1	7.86	26	14.4	14.0	8.3	7.95	25
	2					14.3	14.0	8.1	7.96	25
	3					14.4	14.0	8.1	7.96	25
	Min	15.6	8.7	7.78	26	14.2	14.0	7.7	7.95	25
	Max	15.8	9.7	7.92	30	14.4	14.1	8.3	7.97	29

APPENDIX TABLE 17

Mytilus edulis

SUMMARY OF RESULTS FOR THE BIVALVE LARVAE

REFERENCE TOXICANT (COPPER) BIOASSAY

Test Dates: 4/7-4/9/94

Concentration (µg/L)	Rep	Total Normal	Total Abnormal	Total Larvae/mL	% Survival	% Abnormal	Treatment Mortality (%)
0.56	1	92	5	19.4		5.2	
	2	76	3	15.8		3.8	
	3	86	6	18.4		6.5	
	Mean			17.9	86.3	5.2	12.0
3.2	1	99	24	24.6		19.5	
	2	95	22	23.4		18.8	
	3	89	17	21.2		16.0	
	Mean			23.1	100.0	18.1	0.0
10	1	88	16	20.8		15.4	
	2	11	91	20.4		89.2	
	3	29	45	14.8		60.8	
	Mean			18.7	90.2	55.1	8.0
32	1	0	34	6.8		100.0	
	2	0	12	2.4		100.0	
	3	0	50	10.0		100.0	
	Mean			6.4	30.9	100.0	68.5
56	1	0	0	0.0		100.0	
	2	0	6	1.2		100.0	
	3	0	13	2.6		100.0	
	Mean			1.3	6.1	100.0	93.8

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Appendix 6
Laboratory Results Submitted by ABT - Second Test

RESULTS OF BIOASSAYS CONDUCTED ON TWO HIGH STRENGTH WASTE SAMPLES FROM THE VAN CAMP AND STARKIST TUNA CANNERIES IN AMERICAN SAMOA

Prepared for:

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Oakland, CA 94607
Project # PDX 30702

Prepared by:

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November 21, 1994

Ref: 9309-3

1.0
INTRODUCTION

At the request of CH2M Hill (Project # PDX 30702), Advanced Biological Testing conducted acute effluent bioassay testing on *Mysidopsis bahia*, *Mytilus edulis*, and *Citharichthys stigmaeus* using high strength wastes (HSW) collected separately from the Starkist (HSW-1) and Van Camp (HSW-2) tuna canneries in American Samoa. The study was run using methods generally specified in EPA 1991 and in a Sampling and Testing Plan submitted to the EPA.

The study was conducted at the Advanced Biological Testing Laboratory in Tiburon, California, and was managed by Mr. Mark Fisler.

2.0
METHODS

2.1 EFFLUENT SAMPLING

The high strength wastes were sampled as composites on October 20, 1994 by personnel from the two canneries. Due to shipping and airline scheduling problems, frequently encountered in this region, the sample was received by the laboratory on October 24, 1994. A single gallon carboy was provided from each cannery and were labeled at ABT as HSW-1 (HSW-SKS Grab) and HSW-2 (Pipeline Sludge HS-W2, Van Camp). Samples were maintained in ice-filled coolers from the date of sampling until laboratory receipt. The samples were at 2-3°C upon receipt and were stored at 4°C until use.

2.2 SAMPLE PREPARATION AND TESTING METHODS

2.2.1 Testing on the speckled sanddab, *Citharichthys stigmaeus*

In agreement with the EPA regarding the proposed testing concentrations, the high strength wastes were tested at six concentrations starting from 2.0% and dropping using a 50% dilution factor. The final concentrations were 2.0, 1.0, 0.5, 0.25, 0.125, and 0.06% as vol:vol dilutions in seawater. The diluent was filtered seawater from San Francisco Bay. The dilutions were brought up to the test temperature (17 ± 2°C) and aerated continuously. These effluents have an extremely high biological oxygen demand, therefore aeration was carried out from the beginning of the test.

A reference toxicant was run using concentrations of the toxicant Sodium Dodecyl Sulfonate (SDS) made up as a 2 grams per liter stock solution in distilled water. The tested concentrations were set at 25, 12.5, 6.25, 3.1, and 1.6 mg/L in 30 ppt seawater in a 24 hour test.

The bioassays were carried out on juvenile *Citharichthys stigmaeus*, supplied by J. Brezina and Associates in Dillon Beach, California. The animals were received at ABT on October 24, 1994. The test conditions are summarized in Table 1. Five replicates of each concentration were tested with ten juvenile fish per replicate. Water quality was monitored daily as initial quality on Day 0 and final water quality on Days 1-4. Parameters measured included dissolved oxygen, pH, salinity, total ammonia, and temperature.

2.2.2 Testing on the mysid, *Mysidopsis bahia*

In agreement with the EPA regarding the proposed testing concentrations, the high strength wastes were tested at six concentrations starting from 2.0% and dropping using a 50% dilution factor. The final concentrations were 2.0, 1.0, 0.5, 0.25, 0.125, and 0.06% as vol:vol dilutions in seawater. The diluent was filtered seawater from San Francisco Bay The dilutions were brought up to the test temperature (16 ± 2°C) and aerated continuously.

A reference toxicant was run using concentrations of the toxicant Sodium Dodecyl Sulfonate (SDS) made up as a 2 grams per liter stock solution in distilled water. The tested concentrations were set at 40, 20, 10, 5, 2.5 and 1.25 mg/L in 30 ppt seawater in a 96 hour test.

The first bioassay was carried out on 7-10 day old larval *Mysidopsis bahia*, supplied by Aquatox from Hot Springs, Arkansas. The animals were received at ABT on November 1, 1994. The test conditions for this test are summarized in Table 2. Five replicates of each concentration were tested with ten larval mysids per replicate. Water quality was monitored daily as initial quality on Day 0 and final water quality on Days 1-4. Parameters measured included dissolved oxygen, pH, salinity, total ammonia, and temperature.

2.2.3 Bivalve Larval Bioassay

Test solutions used in the bioassays were prepared using San Francisco Bay seawater at 30 ppt in serial dilution (0.5) to create 2.0, 1.0, 0.5, 0.25, 0.125, and 0.06% test concentrations for the bioassays. The bivalve study was conducted under ASTM 1993 guidelines.

The reference toxicant for the bivalve larval bioassays was copper sulfate at test concentrations of 3.75, 7.5, 15, 30, and 60 µg/L.

The bivalve larvae survival and development test was run following methods in ASTM (1993). Bay mussels, *Mytilus edulis,* were obtained from A. K. Siewers, Santa Cruz, California. Adults were induced to spawn by heat shocking. Released gametes were placed in individual containers of filtered seawater and examined for viability. Gametes were mixed and allowed to fertilize for up to two hours, under gentle aeration. Fertilized eggs were then separated from sperm and debris by filtering the suspension at 20 µm. Egg stock density was estimated by counting an aliquot of dilute stock concentrate. Equal volumes of concentrate were added to each replicate to an initial density of 15-30 embryos per mL. Initial stocking density was confirmed by counting a 5 mL aliquot from at least three control replicates.

Testing was conducted at 16 ± 2°C under a 14 hour light and 10 hour dark photoperiod. Temperature, pH, dissolved oxygen, and salinity were recorded at 0 and 48 hours; temperature was also recorded at 24 hours. Total ammonia in the 2% concentration was 3.6 mg/L at test initiation for HSW-1 and 6.1 mg/L for HSW-2. Ammonia was not measured on Day 2. At the end of the exposure period, a 5 mL sub-sample was taken from each test replicate and preserved with buffered formalin. Sub-samples were counted in a Sedgwick-Rafter cell, and the total number of normal and abnormal larvae were counted.

Gentle aeration was initiated on Day 0, and continued for the duration of the tests. To assess the effects of aeration, an aeration control was run simultaneously. No statistical differences were observed between aerated and unaerated controls.

2.3 STATISTICAL ANALYSIS

At the conclusion of the testing, the survival data were evaluated statistically using ToxCalc™ to determine ECp, NOEC, and LOEC values where appropriate. ToxCalc™ is a comprehensive statistical application that follows standard guidelines for acute and chronic toxicity data analysis. Data were evaluated statistically to estimate the LC50 and IC50 values for the tests using the Probit or Trimmed Spearman-Karber Method.

3.0 RESULTS

3.1 Initial Effluent Quality

The two High Strength Wastes were tested for basic water quality parameters upon receipt at the laboratory. HSW-1 had a dissolved oxygen level of 0.7 mg/L; a pH of 6.53; a salinity of 23.5 ppt; and a total ammonia level of 480 mg/L. HSW-2 had a dissolved oxygen level of 0.6 mg/L; a pH of 6.39; a salinity of 14.0 ppt; and a total ammonia level of 350 mg/L.

3.1 *Citharichthys stigmaeus*

Water quality measurements were within the acceptable limits provided in EPA 1991. Temperature was maintained at 17 ± 2°C; pH remained relatively stable, and the salinity increased slightly as would be expected in a static test. The dissolved oxygen did drop as projected after test initiation in all of the concentration even with supplemental aeration and aeration was maintained in all chambers for the duration of the test. Ammonia was measured in all replicates from each concentration daily and was a potentially significant toxic component of the test for the highest three concentrations.

The LC50 for HSW-1 was 0.35% based upon a Trimmed Spearman-Karber method. The majority of the observed toxicity again occurred in the first 24 hours. There was significant mortality at 2.0, 1.0, and 0.5% concentrations compared to the control at 96 hours. The NOEC was 0.25% and the LOEC was 0.5%

The LC50 for HSW-2 was 0.37% based upon a Trimmed Spearman-Karber method. The majority of the observed toxicity occurred in the first 24 hours. There was significant mortality at 2.0, 1.0, and 0.5% concentrations compared to the control at 96 hours. The NOEC was 0.25%, and the LOEC was 0.5%.

The reference toxicant test required the use of the Trimmed Spearman-Karber method and generated an LC50 of 3.9 mg/L, an NOEC of 3.1 mg/L, and an LOEC of 6.25 mg/L. This is the third reference toxicant test on *Citharichthys* at this laboratory, therefore no database has been established by this laboratory although the data has been consistent in the 3 - 4 mg/L range. The current laboratory mean is 3.92 mg/L.

3.2 *Mysidopsis bahia*

Water quality measurements were within the acceptable limits provided in EPA 1991. Temperature was maintained at 17 ± 2°C; pH remained relatively stable, and the salinity increased slightly as would be expected in a static test. The dissolved oxygen did drop as projected after test initiation in all of the concentration even with supplemental aeration and aeration was maintained in all chambers for the duration of the test. Ammonia was measured in all replicates from each concentration daily and was a potentially significant toxic component of the test for the highest three concentrations.

The LC50 for HSW-1 was 1.16%. At 96 hours, there was significant mortality at 2.0 and 1.0% concentrations compared to the control. The NOEC was 0.5% and the LOEC was 1.0%.

The LC50 for HSW-2 was 0.79%. again there was significant mortality at 96 hours in the 2.0 and 1.0% concentrations compared to the control. The NOEC was 0.5%, and the LOEC was 1.0%.

The reference toxicant test had an LC50 of 7.27 mg/L, with an NOEC of 1.25 mg/L and an LOEC of 2.5 mg/L. This is the third reference toxicant test on *Mysidopsis* at this laboratory, therefore no database has been established. The current mean is 13.5 mg/L.

3.3 BIVALVE LARVAL BIOASSAY

Water quality measurements were within the acceptable limits provided in EPA 1991. Temperature was maintained at 17 ± 2°C; pH remained relatively stable, and the salinity increased slightly as would be expected in a static test. The dissolved oxygen did drop as projected after test initiation in all of the concentration even with supplemental aeration and aeration was maintained in all chambers for the duration of the test. Ammonia was measured in all replicates from each concentration daily and was a potentially significant toxic component of the test for the highest three concentrations.

Control survival was acceptable at 100% with 1.4% abnormal development. The LC50 for HSW-1 was >2.0%, while the LC50 for HSW-2 was 0.2%. The IC50 for HSW-1 was 0.1% and the IC50 for HSW-2 was 0.18%.

The LC50 (6.1 µg/L) for the copper sulfate reference toxicant test was within two standard deviations of the laboratory mean of 15.9 µg/L indicating normal to higher sensitivity of the test organisms.

3.5 AMMONIA MEASUREMENTS

Ammonia in both of the HSW was very high. When measured in a 25% dilution in seawater, ammonia levels ranged from 88 to 120 mg/L. When converted to the 100% concentration, the ammonia level would be above 350 - 450 mg/L. The un-ionized fraction as NH_3 would range from 17 to 24 mg/L at 100% concentration.

TABLE 1

Bioassay Procedure And Organism Data
For the Survival Bioassay
Using *Citharichthys stigmaeus* (U.S. EPA 1991)

Parameter	Data
Test Species	*Citharichthys stigmaeus*
Supplier	J. Brezina and Associates
Collection location	Tomales Bay
Date Acquired	10/25/94
Acclimation Time	24 hours
Acclimation Water	30 ppt seawater
Acclimation Temperature	12 ± 2°C
Age group	Juveniles, 3-5 cm TL
Sample Identification	
Sample ID(s)	941024-19, -20
Date Sampled	10/20/94
Date Received at ABT	10/24/94
Volume Received	One gallon
Sample Storage Conditions	4°C in the dark
Test Procedures	
Type; Duration	96 hour static acute, renewal at 48 hours
Test Dates	10/26/94 to 10/30/94
Control Water	San Francisco Bay seawater
Test Temperature	17 ± 2°C
Test Photoperiod	16 L : 8 D
Initial Salinity	31 ± 2 ppt
Test Chamber	10 L polyethylene chamber
Animals/Replicate	10 animals/replicate
Exposure Volume	5 L
Replicates/Treatment	5
Feeding	None
Deviations from procedures	None

TABLE 2

Bioassay Procedure And Organism Data For the Survival Bioassay Using *Mysidopsis bahia* (U.S. EPA 1991)

Parameter	Data
Test Species	*Mysidopsis bahia*
Supplier	Aquatox, Arkansas
Date Acquired	11/1/94
Acclimation Time	None
Acclimation Water	Shipping water
Acclimation Temperature	20 ± 2°C
Age group	7-10 day larvae
Sample Identification	
Sample ID(s)	941024-19, -20
Date Sampled	10/20/94
Date Received at ABT	10/24/94
Volume Received	Five gallons
Sample Storage Conditions	4°C in the dark
Test Procedures	
Type; Duration	Acute; static; renewal at 48 hours
Test Dates	11/1/94 to 11/5/94
Control Water	San Francisco Bay seawater
Test Temperature	18 ± 2°C
Test Photoperiod	14 L : 10 D
Initial Salinity	30 ppt
Test Chamber	1000 mL jars
Animals/Replicate	10 animal/replicate
Exposure Volume	500 mL
Replicates/Treatment	5
Feeding	Brine shrimp (24 hr old nauplii)
Deviations from procedures	None

TABLE 3

Bioassay Procedure And Organism Data For The 48 Hour Bioassay Using Larvae of *Mytilus edulis* (ASTM 1993)

Parameter	Data
Test Species	*Mytilus edulis*
Supplier	A.K. Siewers, Santa Cruz, CA
Date Acquired	10/25//94
Acclimation Time	None
Acclimation Water	Not applicable
Acclimation Temperature	Not applicable
Age group	Fertilized embryos, 2 hours
Sample Identification	
Sample ID(s)	941024-19, -20
Date Sampled	10/20/94
Date Received at ABT	10/24/94
Volume Received	One gallon
Sample Storage Conditions	4°C in the dark
Test Procedures	
Type; Duration	Acute; static; 48 hours
Test Dates	10/25/94 to 10/27/94
Control Water	San Francisco Bay seawater
Test Temperature	16 ± 2°C
Test Photoperiod	16 L : 8 D
Salinity	32 ± 2 ppt
Test Chamber	125 mL beakers
Animals/Replicate	Approximately 30 embryos per mL
Exposure Volume	100 mL
Replicates/Treatment	3
Feeding	None
Deviations from procedures	Chambers were gently aerated with low bubble aeration

TABLE 4

SUMMARY OF RESULTS FOR THE HIGH STRENGTH WASTE BIOASSAYS

Species	Test	Endpoint	HSW-1	HSW-2
Citharichthys stigmaeus	96 hr static	LC50	0.35%	0.37%
		NOEC	0.25%	0.25%
		LOEC	0.50%	0.50%
Mysidopsis bahia	96 hr static	LC50	1.16%	0.79%
		NOEC	0.50%	0.50%
		LOEC	1.00%	1.00%
Mytilus edulis	48 hr static	LC50	>2.0	0.20%
		IC50	0.10%	0.18%

Note:
HSW-1: Starkist
HSW-2: Van Camp

TABLE 5

SUMMARY OF RESULTS FOR THE REFERENCE TOXICANT TESTS

Citharichthys stigmaeus Concentration (mg/L)	SDS % Survival	LC50 (mg/L)	NOEC (mg/L)	LOEC (mg/L)
Control	100.0	3.9	3.1	6.25
1.6	100.0			
3.1	83.3			
6.25	0.0*			
12.5	0.0*			
25	0.0*			

Lab LC50 = 3.92.

Mysidopsis bahia Concentration (mg/L)	SDS % Survival	LC50 (mg/L)	NOEC (mg/L)	LOEC (mg/L)
Control	98.0	7.27	1.25	2.5
0.7	90.0			
1.25	90.0			
2.5	73.3*			
5	83.3*			
10	70.0*			
20	10.0*			
40	0.0*			

Lab LC50 = 13.52.

Bivalve larvae Concentration (µg/L)	Copper sulfate Mean Normal Larvae/mL	% Treatment Mortality	LC50 (µg/L)	(%) Abnormal
Initial Counts	23.5		6.1	
Control W/Air	23.5	NA		1.4
Control WO/Air	22.9	NA		3.8
3.75	19.0	6.4		1.8
7.5	2.3*	88.5		51.9
15	4.7*	76.7		100
30	0.0*	100.0		100
60	0.0*	100.0		100

* Statistically significant.

4.0 REFERENCES

U.S. EPA. 1991. Methods for measuring acute toxicity of effluents to freshwater and marine organisms, 4th ed. EPA 600/4-90/027, September, 1991.

ASTM. 1993. Annual Book of Standards. Vol. 11.04. Standard guide for conducting static acute toxicity tests starting with embryos of four species of saltwater bivalve mollusca. E-724-89.

APPENDIX A

ANALYTICAL DATA

APPENDIX TABLE 1

SAMPLE WATER QUALITY

Sample	pH (units)	DO (mg/L)	Total NH3 (mg/L)	Initial Salinity (ppt)
HSW-1	6.53	0.7	480	23.5
HSW-2	6.39	0.6	350	14

APPENDIX TABLE 2

Mytilus edulis

WATER QUALITY MEASUREMENTS FOR THE EFFLUENT TEST

Test Dates: 10/25-10/27/94

Concentration (%)	Rep	Day 0 pH	Day 0 DO	Day 0 °C	Day 0 Sal	Day 1 °C	Day 2 pH	Day 2 DO	Day 2 °C	Day 2 Sal
Control W/Air	1	8.06	8.8	16.7	32	16.2	8.00	8.8	16.9	32
	2					16.3	8.01	8.8	16.9	32
	3					16.2	8.02	8.6	16.9	32
Control WO/Air	1	8.06	8.8	16.7	32	16.2	8.09	8.8	16.9	32
	2					16.2	8.11	8.8	16.9	32
	3					16.2	8.13	8.8	16.9	32
HSW-1										
0.06	1	8.04	8.8	16.8	32	16.3	8.12	8.8	16.9	32
	2					16.2	8.09	8.7	16.9	32
	3					16.2	8.11	8.8	16.9	32
0.125	1	7.99	8.8	16.8	32	16.3	8.14	8.6	16.9	32
	2					16.2	8.08	8.6	16.9	33
	3					16.2	8.12	8.7	16.9	32
0.25	1	7.88	8.8	16.7	32	16.2	8.14	8.6	16.9	33
	2					16.2	8.12	8.6	16.9	32
	3					16.3	8.08	8.5	16.9	32
0.5	1	7.68	8.8	16.6	32	16.2	8.02	6.2	16.9	32
	2					16.2	7.75	6.0	16.9	32
	3					16.2	7.68	6.1	16.9	32
1	1	7.34	8.8	16.6	32	16.2	8.01	4.8	16.9	32
	2					16.3	8.00	4.9	16.9	32
	3					16.3	7.93	4.8	16.9	32
2	1	6.96	8.4	16.6	32	16.2	8.04	3.4	16.9	32
	2					16.2	7.99	3.2	16.9	32
	3					16.2	8.05	3.4	16.9	32
	Min	6.96	8.4	16.6	32	16.2	7.68	3.2	16.9	32
	Max	8.06	8.8	16.8	32	16.3	8.14	8.8	16.9	33

APPENDIX TABLE 2 (Cont'd)

Mytilus edulis
WATER QUALITY MEASUREMENTS FOR THE EFFLUENT TEST
Test Dates: 4/7-4/9/94

Concentration		Day 0				Day 1	Day 2			
(%)	Rep	pH	DO	°C	Sal	°C	pH	DO	°C	Sal
HSW-2										
0.06	1	8.06	8.8	16.7	32	16.3	8.12	8.6	16.9	32
	2					16.3	8.15	8.5	16.9	32
	3					16.3	8.16	8.6	16.9	32
0.125	1	8.04	8.9	16.6	32	16.2	8.17	8.5	16.9	32
	2					16.2	8.17	8.5	16.8	32
	3					16.2	8.19	8.5	16.9	32
0.25	1	7.94	8.8	16.7	32	16.2	8.20	8.4	17.0	32
	2					16.2	8.19	8.5	16.9	32
	3					16.3	8.14	8.2	16.9	32
0.5	1	7.77	8.7	16.7	32	16.3	7.73	3.4	16.9	32
	2					16.3	8.11	7.8	16.9	32
	3					16.3	8.15	7.8	16.9	32
1	1	7.40	8.7	16.8	32	16.2	8.09	7.4	17.0	32
	2					16.2	8.19	7.6	16.9	32
	3					16.2	8.20	7.6	16.9	32
2	1	6.92	8.6	16.6	32	16.2	8.03	3.8	16.9	32
	2					16.2	8.03	4.8	16.9	32
	3					16.2	7.98	4.6	16.9	32
	Min	6.92	8.6	16.6	32	16.2	7.73	3.4	16.8	32
	Max	8.06	8.9	16.8	32	16.3	8.20	8.6	17.0	32

APPENDIX TABLE 3

Mytilus edulis
SUMMARY OF RESULTS FOR BIVALVE LARVAE HIGH STRENGTH WASTE BIOASSAY
Test Dates: 10/25-10/27/94

Concentration (%)	Rep	Total Normal	Total Abnormal	Total Larvae/mL	% Survival	% Abnormal	Treatment Mortality (%)
Initial Counts	1	110		22.0			
	2	135		27.0			
	3	108		21.6			
	Mean			23.5			
Final Control W/Air	1	101	0	20.2		0.0	
	2	129	0	25.8		0.0	
	3	117	5	24.4		4.1	
	Mean			23.5	100.0	1.4	NA
Final Control WO/Air	1	104	5	21.8		4.6	
	2	109	3	22.4		2.7	
	3	118	5	24.6		4.1	
	Mean			22.9	100.0	3.8	NA
HSW-1							
0.06	1	82	12	18.8		12.8	
	2	89	14	20.6		13.6	
	3	78	15	18.6		16.1	
	Mean			19.3	93.4	14.2	4.8
0.125	1	23	72	19.0		75.8	
	2	18	58	15.2		76.3	
	3	20	71	18.2		78.0	
	Mean			17.5	84.4	76.7	14.0
0.25	1	3	82	17.0		96.5	
	2	1	77	15.6		98.7	
	3	3	85	17.6		96.6	
	Mean			16.7	80.8	97.3	17.6
0.5	1	0	85	17.0		100.0	
	2	0	93	18.6		100.0	
	3	0	81	16.2		100.0	
	Mean			17.3	83.4	100.0	14.9
1	1	0	89	17.8		100.0	
	2	0	94	18.8		100.0	
	3	0	97	19.4		100.0	
	Mean			18.7	90.2	100.0	8.0
2	1	0	95	19.0		100.0	
	2	0	96	19.2		100.0	
	3	0	87	17.4		100.0	
	Mean			18.5	89.5		8.7

APPENDIX TABLE 3 (Cont'd)

Mytilus edulis

SUMMARY OF RESULTS FOR BIVALVE LARVAE HIGH STRENGTH WASTE BIOASSAY

Test Dates: 10/25-10/27/94

Concentration (%)	Rep	Total Normal	Total Abnormal	Total Larvae/mL	% Survival	% Abnormal	Treatment Mortality (%)
HSW-2							
0.06	1	102	3	21.0		2.9	
	2	87	2	17.8		2.2	
	3	117	3	24.0		2.5	
	Mean			20.9	100.0	2.5	0.0
0.125	1	67	13	16.0		16.3	
	2	61	12	14.6		16.4	
	3	52	12	12.8		18.8	
	Mean			14.5	69.9	17.1	28.7
0.25	1	0	38	7.6		100.0	
	2	0	27	5.4		100.0	
	3	0	33	6.6		100.0	
	Mean			6.5	31.6	100.0	67.8
0.5	1	0	27	5.4		100.0	
	2	0	27	5.4		100.0	
	3	0	27	5.4		100.0	
	Mean			5.4	26.1	100.0	73.4
1	1	0	36	7.2		100.0	
	2	0	39	7.8		100.0	
	3	0	31	6.2		100.0	
	Mean			7.1	34.1	100.0	65.2
2	1	0	37	7.4		100.0	
	2	0	31	6.2		100.0	
	3	0	36	7.2		100.0	
	Mean			6.9	33.5	100.0	65.8

APPENDIX TABLE 4

Mytilus edulis
WATER QUALITY MEASUREMENTS
FOR THE REFERENCE TOXICANT (C0PPER) TEST

Concentration µg/L	Rep	Day 0 pH	Day 0 DO	Day 0 °C	Day 0 Sal	Day 1 °C	Day 2 pH	Day 2 DO	Day 2 °C	Day 2 Sal
3.75	1	8.08	8.8	16.7	32	16.4	8.15	8.4	17.0	32
	2					16.4	8.13	8.5	16.9	32
	3					16.4	8.15	8.6	16.9	32
7.5	1	8.09	8.8	16.7	32	16.5	8.18	8.6	16.9	32
	2					16.4	8.18	8.4	16.9	32
	3					16.5	8.16	8.4	16.9	32
15	1	8.10	8.7	16.7	32	16.5	8.17	8.5	16.9	32
	2					16.5	8.18	8.5	17.0	32
	3					16.5	8.18	8.4	17.0	32
30	1	8.10	8.7	16.8	31	16.5	8.17	8.4	16.9	32
	2					16.5	8.17	8.4	16.9	32
	3					16.5	8.16	8.5	16.9	32
60	1	8.11	8.7	16.7	30	16.5	8.16	8.5	16.9	32
	2					16.4	8.17	8.6	16.9	32
	3					16.5	8.16	8.6	17.0	32
	Min	8.08	8.7	16.7	30	16.4	8.13	8.4	16.9	32
	Max	8.11	8.8	16.8	32	16.5	8.18	8.6	17.0	32

APPENDIX TABLE 5

Mytilus edulis
SUMMARY OF RESULTS FOR THE BIVALVE LARVAE
REFERENCE TOXICANT (COPPER) BIOASSAY

Concentration (µg/L)	Rep	Total Normal	Total Abnormal	Total Larvae/mL	% Survival	% Abnormal	Treatment Mortality (%)
3.75	1	90	2	18.4		2.2	
	2	97	1	19.6		1.0	
	3	93	2	19.0		2.1	
	Mean			19.0	91.8	1.8	6.4
7.5	1	4	5	1.8		55.6	
	2	6	7	2.6		53.8	
	3	7	6	2.6		46.2	
	Mean			2.3	11.3	51.9	88.5
15	1	0	27	5.4		100.0	
	2	0	21	4.2		100.0	
	3	0	23	4.6		100.0	
	Mean			4.7	22.9	100.0	76.7
30	1	0	0	0.0		100.0	
	2	0	0	0.0		100.0	
	3	0	0	0.0		100.0	
	Mean			0.0	0.0	100.0	100.0
60	1	0	0	0.0		100.0	
	2	0	0	0.0		100.0	
	3	0	0	0.0		100.0	
	Mean			0.0	0.0	100.0	100.0

APPENDIX TABLE 6

Mysidopsis bahia
WATER QUALITY MEASUREMENTS FOR EFFLUENT TEST
HSW-1

Concentration				Day 0					Day 1					Day 2					Day 3					Day 4		
(%)	Rep	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal
Control	1	7.98	7.9	0.03	17.1	32	8.18	8.2		17.2	33	8.16	7.2	0.02	17.1	33	8.17	7.3	0.03	17.4	33	8.05	8.0	0.03	17.9	34
	2						8.23	8.1	0.03	17.0	33	8.23	7.2		16.5	33	8.22	7.2		17.1	33	8.14	8.0		17.7	34
	3						8.22	8.1		16.9	32	8.24	7.2		16.3	33	8.24	7.3		16.9	33	8.17	8.0		17.6	34
	4						8.22	8.4		16.6	33	8.24	7.2		16.2	33	8.24	7.4		16.8	33	8.18	8.1		17.5	34
	5						8.22	8.5		16.5	33	8.24	7.4		16.0	33	8.25	7.4		16.6	33	8.20	8.2		17.2	34
0.06	1	7.93	8.0	0.14	17.3	32	8.17	8.5		17.2	33	8.24	7.6	0.11	16.6	33	8.23	7.6	0.11	17.2	34	8.18	8.2	0.10	17.7	34
	2						8.15	8.5	0.10	17.0	32	8.25	7.5		16.5	33	8.20	7.4		17.0	33	8.13	8.2		17.6	34
	3						8.13	8.3		16.8	32	8.23	7.4		16.4	33	8.20	7.4		16.9	33	8.14	8.1		17.6	34
	4						8.20	8.2		16.5	33	8.19	7.4		16.2	33	8.13	7.4		16.6	34	7.98	8.0		17.3	34
	5						8.21	8.2		16.4	31	8.21	7.4		16.0	33	8.16	7.4		16.5	34	8.09	7.8		17.0	34
0.125	1	7.87	8.0	0.27	17.2	32	8.09	8.4		17.2	33	8.22	7.6	0.19	16.6	33	8.21	7.5	0.21	17.2	34	8.15	8.0	0.20	17.6	34
	2						8.02	8.4	0.22	17.0	33	8.24	7.5		16.5	33	8.21	7.4		17.1	33	8.16	8.0		17.6	34
	3						8.01	8.5		16.8	32	8.21	7.4		16.2	33	8.21	7.4		16.8	33	8.14	8.0		17.4	34
	4						8.03	8.3		16.5	33	8.25	7.4		16.0	33	8.25	7.4		16.5	34	8.21	8.0		17.0	34
	5						8.14	8.4		15.9	33	8.25	7.4		16.0	33	8.26	7.4		16.5	34	8.22	8.0		16.9	34
0.25	1	7.72	8.1	0.51	17.2	32	8.01	8.2		17.2	33	8.27	7.6	0.38	16.7	33	8.26	7.6	0.40	17.1	34	8.21	8.2	0.39	17.5	34
	2						8.01	8.2	0.70	17.0	33	8.26	7.6		16.5	33	8.27	7.6		17.0	34	8.20	8.0		17.5	34
	3						7.85	7.7		16.9	32	8.17	7.4		16.4	33	8.21	7.5		16.9	33	8.12	8.0		17.4	34
	4						8.02	7.8		16.5	33	8.23	7.4		16.0	33	8.22	7.4		16.6	34	8.15	7.8		17.0	34
	5						8.09	8.6		16.0	33	8.24	7.4		16.0	33	8.25	7.4		16.4	34	8.19	7.8		16.9	34
0.5	1	7.55	8.1	0.93	17.2	32	7.97	6.6		17.2	33	8.10	7.6	0.70	16.6	33	8.28	7.6	0.60	17.2	33	8.27	8.0	0.74	17.6	34
	2						7.84	7.7	0.40	17.0	32	8.20	7.4		16.5	33	8.23	7.5		17.0	33	8.19	8.0		17.6	34
	3						7.73	6.8		16.9	32	8.16	7.3		16.5	33	8.21	7.4		16.9	33	8.24	7.9		17.4	34
	4						7.78	7.6		16.6	33	8.13	7.2		16.3	33	8.21	7.4		16.6	34	8.18	7.8		17.2	34
	5						7.77	7.9		16.2	33	8.13	7.2		16.0	33	8.20	7.4		16.5	34	8.13	7.8		16.9	34
1	1	7.18	7.8	1.80	17.2	32	7.66	6.9		17.2	32	8.18	7.4	1.44	16.9	33	8.23	7.6	1.26	17.2	33	8.20	7.8	1.18	17.7	34
	2						7.81	7.1	1.50	17.0	32	8.23	7.3		16.6	33	8.28	7.4		17.1	33	8.26	7.8		17.7	34
	3						7.65	6.3		17.0	32	8.18	7.2		16.5	33	8.27	7.4		17.1	33	8.12	7.6		17.6	34
	4						7.60	5.9		16.7	33	8.14	7.2		16.2	33	8.23	7.3		16.7	32	8.17	7.6		17.3	34
	5						7.51	5.2		16.5	33	8.07	7.2		16.0	33	8.16	7.3		16.3	34	8.14	7.4		17.0	34
2.0	1	6.84	7.7	3.60	17.2	32	7.56	3.5		15.9	33	8.22	7.2	2.82	16.0	33	8.30	7.3	2.16	16.3	34	8.31	7.4	2.07	16.8	34
	2						7.47	2.0	3.70	15.7	33	8.09	7.2		16.0	34	—	—	—	—	—	—	—	—	—	—
	3						7.49	2.0		15.6	33	8.05	6.7		16.0	34	—	—	—	—	—	—	—	—	—	—
	4						7.38	0.6		15.8	33	8.14	6.7		16.0	34	—	—	—	—	—	—	—	—	—	—
	5						7.66	3.8		15.9	34	8.18	6.9		16.0	34	8.30	7.4		16.2	34	8.31	7.6		16.7	34
Min		6.84	7.7	0.03	17.1	32	7.38	0.6	0.03	15.6	31	8.05	6.7	0.02	16.0	33	8.13	7.2	0.03	16.2	32	7.98	7.4	0.03	16.7	34
Max		7.98	8.1	3.60	17.3	32	8.23	8.6	3.70	17.2	34	8.27	7.6	2.82	17.1	34	8.30	7.6	2.16	17.4	34	8.31	8.2	2.07	17.9	34

Note: — = All animals dead.

APPENDIX TABLE 6 (Cont'd)

Mysidopsis bahia
WATER QUALITY MEASUREMENTS FOR EFFLUENT TEST
HSW-2

Concentration (%)	Rep	Day 0 pH	Day 0 DO	Day 0 NH3	Day 0 °C	Day 0 Sal	Day 1 pH	Day 1 DO	Day 1 NH3	Day 1 °C	Day 1 Sal	Day 2 pH	Day 2 DO	Day 2 NH3	Day 2 °C	Day 2 Sal	Day 3 pH	Day 3 DO	Day 3 NH3	Day 3 °C	Day 3 Sal	Day 4 pH	Day 4 DO	Day 4 NH3	Day 4 °C	Day 4 Sal
0.06	1	7.84	8.1	0.24	17.6	32	8.15	8.1		17.2	33	8.26	7.2	0.16	16.6	33	8.28	7.6	0.20	17.1	34	8.27	8.2	0.18	17.6	34
	2						8.02	8.0	0.28	16.9	33	8.19	7.2		16.4	33	8.20	7.5		16.9	34	8.18	8.1		17.4	34
	3						8.18	8.0		16.5	33	8.24	7.2		16.0	33	8.26	7.4		16.7	34	8.24	8.1		17.2	34
	4						8.20	8.1		16.3	33	8.26	7.4		16.0	33	8.26	7.4		16.5	34	8.26	8.0		17.0	34
	5						8.20	8.0		16.2	34	8.25	7.4		16.0	33	8.15	7.5		16.5	34	8.27	8.0		17.0	34
0.125	1	7.79	8.1	0.47	17.7	32	8.12	8.1		17.2	33	8.25	7.5	0.27	16.5	34	8.28	7.4	0.32	17.0	34	8.27	8.2	0.28	17.4	34
	2						8.11	8.0	0.32	16.9	33	8.25	7.4		16.4	33	8.27	7.4		16.8	34	8.26	8.2		17.4	34
	3						8.05	8.0		16.6	33	8.21	7.4		16.2	33	8.26	7.4		16.6	34	8.12	8.0		17.2	34
	4						8.15	8.0		16.2	33	8.23	7.3		16.1	33	8.26	7.4		16.5	34	8.21	7.6		17.0	34
	5						8.17	8.1		16.2	33	8.27	7.4		16.0	34	8.27	7.6		16.5	34	8.26	7.6		16.9	34
0.25	1	7.66	8.0	0.84	17.6	32	7.95	7.8		17.1	33	8.24	7.4	0.54	16.4	33	8.26	7.6	0.51	16.9	34	8.25	8.0	0.47	17.4	34
	2						7.89	7.8	0.60	16.9	33	8.18	7.4		16.3	33	8.24	7.4		16.9	34	8.20	8.0		17.4	34
	3						7.93	7.8		16.6	33	8.20	7.2		16.2	33	8.24	7.4		16.6	34	8.21	7.9		17.2	34
	4						7.92	7.8		16.5	33	8.20	7.2		16.1	33	8.22	7.4		16.5	34	8.19	7.8		17.0	34
	5						8.01	7.8		16.2	33	8.20	7.2		16.0	34	8.25	7.4		16.5	34	8.23	7.8		16.9	34
0.5	1	7.43	7.9	1.60	17.6	32	7.89	7.8		17.1	33	8.25	7.4	1.10	16.2	33	8.27	7.5	1.05	16.8	34	8.26	8.0	0.98	17.2	34
	2						7.83	7.8	1.21	16.9	33	8.21	7.4		16.2	33	8.27	7.4		16.7	34	8.27	7.9		17.2	34
	3						7.79	7.4		16.7	33	8.20	7.2		16.1	33	8.27	7.4		16.6	34	8.23	7.8		17.2	34
	4						7.77	7.4		16.5	33	8.16	7.2		16.0	33	8.25	7.4		16.5	34	8.21	7.6		17.0	34
	5						7.94	7.8		16.2	33	8.24	7.2		16.0	34	8.30	7.4		16.5	34	8.28	7.6		16.9	34
1	1	7.10	7.8	3.20	17.6	32	7.64	5.8		16.9	33	8.25	7.3	2.21	16.0	34	—	—	—	—	—	—	—	—	—	—
	2						7.50	0.8	2.57	16.9	33	8.15	7.3		16.0	33	—	—	—	—	—	—	—	—	—	—
	3						7.62	5.2		16.6	33	8.20	7.2		16.0	33	8.24	7.4	2.05	16.5	34	8.28	7.8	2.01	17.0	34
	4						7.62	5.0		16.4	33	8.21	7.2		16.1	33	8.29	7.4		16.5	34	8.31	7.6		16.9	34
	5						7.67	4.8		16.2	33	8.17	7.2		16.0	34	8.25	7.3		16.5	34	8.22	7.6		16.9	34
2.0	1	6.82	7.2	6.10	17.9	32	7.45	0.8		17.0	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.49	0.4	5.28	16.7	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.40	0.6		16.5	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.57	1.8		16.3	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.47	0.6		16.2	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Min		6.82	7.2	0.24	17.6	32	7.40	0.4	0.28	16.2	33	8.15	7.2	0.16	16.0	33	8.15	7.3	0.20	16.5	34	8.12	7.6	0.18	16.9	34
Max		7.84	8.1	6.10	17.9	32	8.20	8.1	5.28	17.2	34	8.27	7.5	2.21	16.6	34	8.30	7.6	2.05	17.1	34	8.31	8.2	2.01	17.6	34

Note: — = All animals dead.

APPENDIX TABLE 7

Mysidopsis bahia
SURVIVAL DATA FOR EFFLUENT TEST
HSW-1

Concentration (%)	Rep	Initial Added	Day 1	Day 2	Day 3	Day 4	% Survival	Average % Survival
Control	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	9	9	9	90	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	98.0
0.06	1	10	10	9	9	9	90	
	2	10	10	9	10	10	100	
	3	10	10	10	9	9	90	
	4	10	9	9	8	8	80	
	5	10	9	9	9	9	90	90.0
0.125	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	100.0
0.25	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	100.0
0.5	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	9	9	90	98.0
1	1	10	10	10	10	9	90	
	2	10	10	10	10	6	60	
	3	10	10	10	10	7	70	
	4	10	10	10	.10	6	60	
	5	10	10	8	6	5	50	66.0
2	1	10	*	3	3	1	10	
	2	10	*	0	—	—	0	
	3	10	*	0	—	—	0	
	4	10	*	0	—	—	0	
	5	10	*	2	2	1	10	4.0

Notes: — = All animals dead.
* Sample too turbid to do counts.

APPENDIX TABLE 7 (Cont'd)

Mysidopsis bahia
SURVIVAL DATA FOR EFFLUENT TEST
HSW-2

Concentration (%)	Rep	Initial Added	Day 1	Day 2	Day 3	Day 4	% Survival	Average % Survival
0.06	1	10	10	10	10	10	100	
	2	10	10	7	6	5	50	
	3	10	10	10	10	10	100	
	4	10	10	7	7	6	60	
	5	10	10	9	9	9	90	80.0
0.125	1	10	10	10	10	10	100	
	2	10	10	9	9	8	80	
	3	10	10	10	10	9	90	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	94.0
0.25	1	10	10	10	10	9	90	
	2	10	10	10	10	9	90	
	3	10	10	10	9	9	90	
	4	10	10	10	9	9	90	
	5	10	10	8	8	7	70	86.0
0.5	1	10	10	9	9	9	90	
	2	10	10	10	9	9	90	
	3	10	10	10	9	9	90	
	4	10	10	10	10	9	90	
	5	10	10	9	9	8	80	88.0
1	1	10	*	0	—	—	0	
	2	10	*	0	—	—	0	
	3	10	*	2	2	3	30	
	4	10	*	2	2	2	20	
	5	10	*	2	2	2	20	14.0
2	1	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0

Notes: — = All animals dead.
* Sample too turbid to do counts.

APPENDIX TABLE 8

Mysidopsis bahia
WATER QUALITY MEASUREMENTS
FOR REFERENCE TOXICANT (S.D.S) TEST

Concentration		Day 0				Day 1				Day 2				Day 3				Day 4			
(mg/L)	Rep	pH	DO	°C	Sal	pH	DO	°C	Sal	pH	DO	°C	Sal	pH	DO	°C	Sal	pH	DO	°C	Sal
0.7	1	8.06	8.2	15.9	33	8.16	7.2	17.4	33	8.16	7.2	17.4	33	8.03	7.4	17.6	33	7.88	6.8	18.2	33
	2					8.19	7.1	17.2	33	8.16	7.2	17.3	33	8.07	7.4	17.6	33	7.91	6.7	18.2	33
	3					8.20	7.1	17.3	33	8.16	7.1	17.3	33	8.06	7.2	17.6	33	7.88	6.6	18.2	33
1.25	1	8.07	8.1	15.9	32	8.19	7.0	17.2	33	8.17	7.0	17.3	33	8.08	7.2	17.6	33	7.93	6.5	18.2	33
	2					8.19	7.0	17.0	33	8.16	7.0	17.2	33	8.07	7.2	17.6	33	7.93	6.6	18.0	33
	3					8.19	7.0	17.1	33	8.15	7.1	17.2	33	8.07	7.2	17.5	33	7.93	6.6	18.0	33
2.5	1	8.07	8.1	15.8	32	8.16	6.9	17.2	33	8.13	7.0	17.3	33	8.05	7.2	17.6	33	7.93	6.7	18.2	33
	2					8.15	6.5	17.0	33	8.12	7.0	17.0	33	8.05	7.2	17.5	33	7.96	6.6	18.0	33
	3					8.14	6.4	17.0	33	8.12	7.0	17.1	33	8.03	7.2	17.6	33	7.89	6.7	18.0	33
5	1	8.08	8.1	15.9	32	8.11	6.4	17.2	33	8.08	7.0	17.4	33	8.02	7.2	17.6	33	7.90	6.5	18.3	33
	2					8.11	6.0	17.0	33	8.08	6.8	17.3	33	8.01	7.0	17.6	33	7.91	6.5	18.1	33
	3					8.10	5.8	17.0	33	8.09	6.8	17.2	33	8.00	7.0	17.6	33	7.89	6.4	18.2	33
10	1	8.08	8.0	15.8	32	8.05	5.8	17.3	33	8.01	6.4	17.5	33	7.98	7.0	17.9	33	7.89	6.4	18.6	33
	2					8.07	5.8	17.1	33	7.99	6.4	17.3	33	7.98	7.0	17.8	33	7.89	6.4	18.3	33
	3					8.08	5.1	17.2	33	7.98	6.4	17.3	33	7.98	7.0	17.6	33	7.87	6.4	18.3	33
20	1	8.09	8.0	15.8	32	8.05	4.8	17.5	33	7.80	4.5	17.7	33	—	—	—	—	—	—	—	—
	2					8.06	4.7	17.3	33	7.77	4.4	17.6	33	7.83	7.1	18.0	33	7.85	6.4	18.7	33
	3					8.05	4.7	17.2	33	7.78	4.4	17.4	33	7.81	6.4	17.8	33	7.92	6.7	18.6	34
40	1	8.09	8.1	15.7	32	8.12	6.0	17.8	33	—	—	—	—	—	—	—	—	—	—	—	—
	2					8.17	6.2	17.8	33	—	—	—	—	—	—	—	—	—	—	—	—
	3					8.17	6.2	17.8	33	—	—	—	—	—	—	—	—	—	—	—	—
Min		8.06	8.0	15.7	32	8.05	4.7	17.0	33.0	7.77	4.4	17.0	33.0	7.81	6.4	17.5	33.0	7.85	6.4	18.0	33.0
Max		8.09	8.2	15.9	33	8.20	7.2	17.8	33.0	8.17	7.2	17.7	33.0	8.08	7.4	18.0	33.0	7.96	6.8	18.7	34.0

Note: — = All animals dead.

APPENDIX TABLE 9

Mysidopsis bahia

SURVIVAL DATA FOR REFERENCE TOXICANT (S.D.S.) TEST

Concentration (mg/L)	Rep	Initial Added	Day 1	Day 2	Day 3	Day 4	% Survival	Average % Survival
0.7	1	10	10	9	8	8	80	
	2	10	10	10	10	10	100	
	3	10	10	9	9	9	90	90.0
1.25	1	10	10	9	9	9	90	
	2	10	10	9	9	9	90	
	3	10	10	10	10	9	90	90.0
2.5	1	10	10	8	8	8	80	
	2	10	10	7	7	7	70	
	3	10	9	8	8	7	70	73.3
5	1	10	10	10	10	10	100	
	2	10	10	7	7	6	60	
	3	10	9	9	9	9	90	83.3
10	1	10	10	9	8	8	80	
	2	10	8	7	7	7	70	
	3	10	8	7	6	6	60	70.0
20	1	10	2	0	—	—	0	
	2	10	2	2	2	2	20	
	3	10	1	1	1	1	10	10.0
40	1	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	0.0

Note: — = All animals dead.

APPENDIX TABLE 10

Citharichthys stigmaeus
WATER QUALITY MEASUREMENTS FOR EFFLUENT TEST
Study Dates: 10/26-10/30/94
HSW-1

Concentration (%)	Rep	Day 0 pH	Day 0 DO	Day 0 NH3	Day 0 °C	Day 0 Sal	Day 1 pH	Day 1 DO	Day 1 NH3	Day 1 °C	Day 1 Sal	Day 2 pH	Day 2 DO	Day 2 NH3	Day 2 °C	Day 2 Sal	Day 3 pH	Day 3 DO	Day 3 NH3	Day 3 °C	Day 3 Sal	Day 4 pH	Day 4 DO	Day 4 NH3	Day 4 °C	Day 4 Sal
Control	1	8.02	8.6	<0.01	16.5	32	8.05	8.2	0.08	16.8	32	8.03	8.8	0.08	14.6	33	7.94	6.8	0.08	15.4	33	7.95	8.2	0.09	15.7	33
	2						7.92	8.3	0.08	16.9	32	7.82	8.8	0.09	14.7	33	7.78	7.0	0.09	15.5	33	7.81	8.2	0.14	15.7	33
	3						7.91	7.8	0.07	16.9	32	7.84	9.0	0.09	14.6	33	7.79	6.8	0.07	15.5	33	7.81	7.2	0.19	15.7	33
	4						8.04	8.1	0.07	16.8	32	7.99	8.7	0.08	14.5	33	8.00	6.6	0.07	15.4	33	7.99	8.1	0.18	15.6	33
	5						8.00	8.2	0.07	16.8	32	7.99	8.8	0.09	14.6	33	7.94	6.6	0.08	15.4	33	7.97	8.1	0.17	15.6	33
0.06	1	7.95	8.6	0.16	16.4	32	7.90	8.1	0.14	16.7	32	8.00	9.0	0.17	14.6	33	7.99	7.2	0.16	15.4	33	8.00	8.1	0.29	15.7	33
	2						7.89	8.0	0.14	16.6	32	8.01	9.0	0.17	14.5	33	8.00	7.2	0.18	15.5	33	8.03	8.1	0.26	15.6	34
	3						7.95	8.0	0.14	16.5	32	8.04	9.0	0.17	14.5	33	8.04	7.0	0.14	15.4	33	8.06	8.3	0.29	15.5	34
	4						7.83	7.6	0.15	16.3	32	8.02	9.0	0.18	14.2	33	7.94	7.2	0.18	15.3	33	7.95	8.2	0.30	15.2	34
	5						7.82	7.8	0.15	16.2	32	7.97	8.9	0.18	14.2	33	7.93	7.2	0.17	15.4	33	7.96	7.9	0.31	15.0	33
0.125	1	7.93	8.6	0.23	16.4	32	7.61	5.1	0.21	16.3	32	7.99	8.9	0.21	14.2	33	7.98	7.4	0.20	15.4	33	8.01	8.1	0.35	15.3	34
	2						7.59	5.0	0.22	16.2	32	7.99	9.0	0.24	14.2	33	7.95	7.2	0.24	15.2	33	8.01	8.1	0.40	15.2	34
	3						7.76	7.2	0.22	16.0	32	8.01	9.1	0.23	14.2	33	7.97	7.2	0.20	15.4	33	8.03	8.2	0.48	15.4	34
	4						7.64	5.6	0.19	16.2	32	8.01	9.1	0.23	14.3	33	7.97	7.0	0.19	15.2	33	8.00	8.1	0.53	15.3	34
	5						7.86	7.3	0.19	16.2	32	8.03	9.1	0.23	14.2	33	8.04	7.0	0.21	15.3	33	8.08	8.0	0.51	15.2	34
0.25	1	7.83	8.6	0.47	16.5	32	7.58	4.6	0.35	16.0	32	7.94	9.0	0.37	13.9	34	7.90	7.2	0.34	15.3	33	7.97	8.1	0.53	14.5	36
	2						7.65	4.7	0.36	16.0	32	8.04	8.8	0.37	14.0	33	8.01	7.3	0.33	15.3	33	8.10	8.0	0.62	14.7	35
	3						7.62	4.6	0.35	16.0	32	8.07	8.9	0.36	14.3	33	8.03	7.3	0.37	15.4	33	8.10	8.2	0.57	14.9	34
	4						7.67	4.7	0.34	15.9	32	8.03	9.0	0.36	14.4	33	7.92	7.3	0.36	15.4	33	8.03	8.2	0.66	15.1	34
	5						7.67	4.8	0.34	16.0	32	8.08	9.1	0.36	14.3	33	8.05	7.2	0.37	15.3	33	8.11	8.3	0.61	14.9	35
0.5	1	7.63	8.5	0.92	16.4	32	7.50	1.2	0.74	16.5	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.50	0.9	0.67	16.6	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.52	0.8	0.76	16.6	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.51	1.3	0.75	16.6	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.57	1.0	0.66	16.6	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	1	7.33	8.5	1.98	16.4	31	7.45	0.8	1.58	16.5	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.46	0.9	1.62	16.5	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.47	0.6	1.59	16.5	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.48	0.8	1.54	16.4	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.46	0.8	1.63	16.2	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	1	6.99	8.1	3.95	16.5	31	7.41	0.6	3.18	16.2	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.40	0.4	3.20	16.2	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.48	0.6	3.12	16.0	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.41	0.8	3.15	16.1	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.45	0.8	3.19	16.2	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Min		6.99	8.1	<0.10	16.4	31	7.40	0.4	0.07	15.9	32	7.82	8.7	0.08	13.9	33	7.78	6.6	<0.10	15.2	33	7.81	7.2	0.09	14.5	33
Max		8.02	8.6	3.95	16.5	32	8.05	8.3	3.20	16.9	32	8.08	9.1	0.37	14.7	34	8.05	7.4	0.37	15.5	33	8.11	8.3	0.66	15.7	36

Note: — = All animals dead.

APPENDIX TABLE 10 (Cont'd)

Citharichthys stigmaeus
WATER QUALITY MEASUREMENTS FOR EFFLUENT TEST
Study Dates: 10/26-10/30/94
HSW-2

Concentration (%)	Rep	Day 0 pH	Day 0 DO	Day 0 NH3	Day 0 °C	Day 0 Sal	Day 1 pH	Day 1 DO	Day 1 NH3	Day 1 °C	Day 1 Sal	Day 2 pH	Day 2 DO	Day 2 NH3	Day 2 °C	Day 2 Sal	Day 3 pH	Day 3 DO	Day 3 NH3	Day 3 °C	Day 3 Sal	Day 4 pH	Day 4 DO	Day 4 NH3	Day 4 °C	Day 4 Sal
0.06	1	8.00	8.5	0.19	16.5	32	7.76	7.0	0.20	16.5	32	8.03	9.2	0.17	14.8	32	8.07	7.4	0.17	15.5	33	8.09	8.2	0.17	15.5	33
	2						7.84	7.2	0.17	16.4	32	8.03	9.1	0.17	14.4	33	8.04	7.2	0.16	15.4	33	8.08	8.3	0.20	15.5	33
	3						7.84	7.2	0.18	16.3	32	8.02	9.1	0.18	14.2	33	8.05	7.2	0.18	15.5	33	8.08	8.3	0.21	15.3	34
	4						7.75	6.2	0.17	16.4	32	8.00	9.0	0.18	14.2	33	8.01	7.0	0.17	15.5	33	8.06	8.2	0.19	15.2	34
	5						7.79	6.6	0.18	15.9	32	8.04	8.9	0.18	14.5	33	8.05	7.1	0.19	15.4	33	8.10	8.2	0.23	14.4	36
0.125	1	7.94	8.6	0.30	16.5	32	7.70	6.4	0.27	16.2	32	7.99	8.9	0.26	14.2	33	8.02	7.5	0.21	15.4	33	8.06	8.3	0.31	15.3	34
	2						7.81	6.2	0.27	16.3	32	8.03	9.1	0.27	14.3	33	8.04	7.3	0.25	15.4	33	8.09	8.1	0.34	15.3	34
	3						7.81	6.0	0.27	16.4	32	8.04	9.2	0.26	14.3	33	8.05	7.2	0.25	15.5	33	8.10	8.3	0.29	15.3	34
	4						7.58	6.1	0.29	15.9	32	8.04	9.2	0.26	13.8	33	8.06	7.2	0.27	15.3	33	8.11	8.3	0.31	14.8	35
	5						7.76	6.2	0.29	15.9	32	8.06	9.2	0.25	13.8	33	8.07	7.2	0.27	15.3	33	8.13	8.3	0.34	14.8	34
0.25	1	7.79	8.6	0.62	16.4	32	7.70	4.2	0.57	15.9	32	7.94	9.2	0.47	13.9	33	8.00	7.4	0.44	15.2	33	8.05	8.3	0.47	14.9	34
	2						7.70	4.5	0.58	15.9	32	7.91	8.9	0.47	13.8	33	7.96	7.2	0.41	15.3	33	8.02	8.2	0.49	14.9	34
	3						7.64	4.6	0.55	15.9	32	7.98	8.8	0.47	13.8	33	7.99	7.2	0.41	15.3	33	8.07	8.0	0.41	14.8	34
	4						7.61	4.6	0.53	16.1	32	7.89	8.8	0.46	14.0	33	7.92	7.3	0.40	15.3	33	8.00	8.1	0.47	15.2	34
	5						7.59	4.6	0.52	16.2	32	7.92	8.8	0.47	14.2	33	7.91	7.2	0.43	15.3	33	7.98	7.9	0.49	15.2	34
0.5	1	7.54	8.7	1.24	16.5	32	7.57	1.6	1.07	16.2	32	7.97	8.7	0.87	14.0	33	8.04	7.0	0.79	15.4	33	8.08	8.2	0.74	14.9	34
	2						7.49	1.8	1.16	16.2	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.54	1.8	1.09	16.2	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.56	1.8	1.08	16.2	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.57	1.9	1.03	16.3	32	8.05	8.8	0.86	14.2	33	8.09	7.0	0.83	15.4	33	8.15	8.2	0.69	15.0	35
1	1	7.23	8.6	2.41	16.5	32	7.61	0.9	2.10	16.2	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.62	0.9	2.24	16.3	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.54	1.0	2.22	16.4	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.54	0.8	2.31	15.8	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.51	0.8	2.31	15.7	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2.0	1	6.86	8.3	5.15	16.5	31	7.80	0.6	4.88	15.8	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.56	0.6	4.47	15.9	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.60	0.8	4.65	15.9	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.60	0.8	4.40	16.0	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.56	0.6	4.32	16.2	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Min		6.86	8.3	0.19	16.4	31	7.49	0.6	0.17	15.7	32	7.89	8.7	0.17	13.8	32	7.91	7.0	<0.10	15.2	33	7.98	7.9	0.19	14.4	33
Max		8.00	8.7	5.15	16.5	32	7.84	7.2	4.88	16.5	32	8.06	9.2	0.87	14.8	33	8.09	7.5	0.83	15.5	33	8.15	8.3	0.74	15.5	36

Note: — = All animals dead.

APPENDIX TABLE 11

Citharichthys stigmaeus
SURVIVAL DATA FOR EFFLUENT TEST
HSW-1

Concentration (%)	Rep	Initial Added	Day 1	Day 2	Day 3	Day 4	% Survival	Average % Survival
Control	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	100.0
0.06	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	100.0
0.125	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	100.0
0.25	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	100.0
0.5	1	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0
1	1	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0
2	1	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0

Note: — = All animals dead.

APPENDIX TABLE 11 (Cont'd)

Citharichthys stigmaeus
SURVIVAL DATA FOR EFFLUENT TEST
HSW-2

Concentration (%)	Rep	Initial Added	Day 1	Day 2	Day 3	Day 4	% Survival	Average % Survival
0.06	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	100.0
0.125	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	9	10	10	100	100.0
0.25	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	100.0
0.5	1	10	4	2	2	2	20	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	2	2	2	2	20	8.0
1	1	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0
2	1	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0

Note: — = All animals dead.

APPENDIX TABLE 12

Citharichthys stigmaeus
WATER QUALITY MEASUREMENTS
FOR REFERENCE TOXICANT (S.D.S) TEST

Concentration		Day 0				Day 1			
(mg/L)	Rep	pH	DO	°C	Sal	pH	DO	°C	Sal
Control	1	7.93	9.4	15.4	31	7.75	5.0	NT	NT
	2					7.73	4.8	NT	NT
	3					7.69	4.8	NT	NT
1.6	1	7.94	9.4	15.2	31	7.62	4.0	NT	NT
	2					7.68	4.4	NT	NT
	3					7.70	4.4	NT	NT
3.1	1	7.95	9.4	15.2	31	7.59	4.1	NT	NT
	2					7.61	4.3	NT	NT
	3					7.64	4.4	NT	NT
6.25	1	7.95	9.4	15.2	31	7.42	2.1	NT	NT
	2					7.72	2.1	NT	NT
	3					7.75	2.2	NT	NT
12.5	1	7.96	9.4	15.2	31	7.42	2.0	NT	NT
	2					7.59	2.1	NT	NT
	3					7.56	2.1	NT	NT
25	1	7.96	9.4	15.2	31	7.40	2.0	NT	NT
	2					7.43	2.0	NT	NT
	3					7.48	2.0	NT	NT
Min		7.93	9.4	15.2	31	7.40	2.0		
Max		7.96	9.4	15.4	31	7.75	5.0		

Note: NT = Not taken.

APPENDIX TABLE 13

Citharichthys stigmaeus
SURVIVAL DATA
FOR REFERENCE TOXICANT (S.D.S.) TEST

Concentration (mg/L)	Rep	Initial Added	Day 1	% Survival	Average % Survival
Control	1	6	6	100	
	2	6	6	100	
	3	6	6	100	100.0
1.6	1	6	6	100	
	2	6	6	100	
	3	6	6	100	100.0
3.1	1	6	5	83	
	2	6	5	83	
	3	6	5	83	83.3
6.25	1	6	0	0	
	2	6	0	0	
	3	6	0	0	0.0
12.5	1	6	0	0	
	2	6	0	0	
	3	6	0	0	0.0
25	1	6	0	0	
	2	6	0	0	
	3	6	0	0	0.0

Appendix 7
Laboratory Results Submitted by ABT - Third Test

RESULTS OF BIOASSAYS CONDUCTED ON TWO HIGH-STRENGTH WASTE SAMPLES FROM THE VAN CAMP AND STARKIST TUNA CANNERIES IN AMERICAN SAMOA

Prepared for:

CH2M Hill California, Inc.
1111 Broadway
Oakland, CA 94607
Project # PDX 30702

Prepared by:

Advanced Biological Testing Inc.
98 Main St., # 419
Tiburon, Ca. 94920

July 10, 1995

Ref: 9309-8

1.0
INTRODUCTION

At the request of CH2M Hill (Project # PDX 30702), Advanced Biological Testing conducted acute effluent bioassay testing on *Mysidopsis bahia* and *Citharichthys stigmaeus* using high strength wastes (HSW) collected separately from the Starkist (HSW-1) and Van Camp (HSW-2) tuna canneries in American Samoa. The study was run using methods generally specified in EPA 1991 and in a Sampling and Testing Plan submitted to the EPA.

The study was conducted at the Advanced Biological Testing Laboratory in Tiburon, California, and was managed by Mr. Mark Fisler.

2.0 METHODS

2.1 EFFLUENT SAMPLING

The high strength wastes were sampled as composites on June 23, 1995 by personnel from the two canneries. Due to shipping and airline scheduling problems, frequently encountered in this region, the sample was received by the laboratory on June 26, 1995. A single gallon carboy was provided from each cannery and were labeled at ABT as HSW-1 (HSW-SKS Grab) and HSW-2 (Pipeline Sludge HS-W2, Van Camp). Samples were maintained in ice-filled coolers from the date of sampling until laboratory receipt. The samples were at 2-3°C upon receipt and were stored at 4°C until use.

2.2 SAMPLE PREPARATION AND TESTING METHODS

2.2.1 Testing on the speckled sanddab, *Citharichthys stigmaeus*

The bioassays were carried out on juvenile *Citharichthys stigmaeus*, supplied by J. Brezina and Associates in Dillon Beach, California. The animals were received at ABT on June 25, 1995. The test conditions are summarized in Table 1. Five replicates of each concentration were tested with ten juvenile fish per replicate. Water quality was monitored daily. Parameters measured included dissolved oxygen, pH, salinity, total ammonia, and temperature. In agreement with the EPA regarding the proposed testing concentrations, the high strength wastes were tested at six concentrations starting from 2.0% and dropping using a 50% dilution factor. The final concentrations were 2.0, 1.0, 0.5, 0.25, 0.125, and 0.06% as vol:vol dilutions in seawater. The diluent was filtered seawater from San Francisco Bay. The dilutions were brought up to the test temperature (17 ± 2°C) and aerated continuously. These effluents have an extremely high biological oxygen demand, therefore aeration was carried out from the beginning of the test.

A reference toxicant was run using concentrations of the toxicant Sodium Dodecyl Sulfonate (SDS) made up as a 2 grams per liter stock solution in distilled water. The tested concentrations were set at 25, 12.5, 6.25, 3.1, and 1.6 mg/L in 30 ppt seawater in a 24 hour test.

2.2.2 Testing on the mysid, *Mysidopsis bahia*

The bioassay was carried out on 3-5 day old larval *Mysidopsis bahia*, supplied by Aquatox from Hot Springs, Arkansas. The animals were received at ABT on June 27, 1994. The test conditions for this test are summarized in Table 2. Five replicates of each concentration were tested with ten larval mysids per replicate. Water quality was monitored daily as initial quality on Day 0 and final water quality on Days 1-4. Parameters measured included dissolved oxygen, pH, salinity, total ammonia, and temperature. In agreement with the EPA regarding the proposed testing concentrations, the high strength wastes were tested at six concentrations starting from 2.0% and dropping using a 50% dilution factor. The final concentrations were 2.0, 1.0, 0.5, 0.25, 0.125, and 0.06% as vol:vol dilutions in seawater. The diluent was filtered seawater from San Francisco Bay The dilutions were brought up to the test temperature (16 ± 2°C) and aerated continuously.

A reference toxicant was run using concentrations of the toxicant Sodium Dodecyl Sulfonate (SDS) made up as a 2 grams per liter stock solution in distilled water. The tested concentrations were set at 40, 20, 10, 5, 2.5 and 1.25 mg/L in 30 ppt seawater in a 96 hour test.

2.3 STATISTICAL ANALYSIS

At the conclusion of the testing, the survival data were evaluated statistically using ToxCalc™ to determine ECp, NOEC, and LOEC values where appropriate. ToxCalc™ is a comprehensive statistical application that follows standard guidelines for acute and chronic toxicity data analysis. Data were evaluated statistically to estimate the LC50 values for the tests using the Linear Interpolation (Bootstrap) or Trimmed Spearman-Karber methods.

3.0 RESULTS

3.1 Initial Effluent Quality

The two High Strength Wastes were tested for basic water quality parameters upon receipt at the laboratory. HSW-1 had a dissolved oxygen level of 0.8 mg/L; a pH of 6.49; a salinity of 23 ppt; and a total ammonia level of 380 mg/L. HSW-2 had a dissolved oxygen level of 1.4 mg/L; a pH of 6.71; a salinity of 17.0 ppt; and a total ammonia level of 220 mg/L.

3.2 *Citharichthys stigmaeus*

Water quality measurements were within the acceptable limits provided in EPA 1991. Temperature was maintained at 17 ± 2°C; pH remained relatively stable, and the salinity increased slightly as would be expected in a static test. The dissolved oxygen did drop as projected after test initiation in all of the concentration even with supplemental aeration and aeration was maintained in all chambers for the duration of the test. Ammonia was measured in all replicates from each concentration daily and was a potentially significant toxic component of the test for the highest three concentrations.

The LC50 for HSW-1 was 0.396% based upon a Trimmed Spearman-Karber method. The majority of the observed toxicity again occurred in the first 24 hours. There was significant mortality at 2.0, 1.0, and 0.5% concentrations compared to the control at 96 hours. The NOEC was 0.25% and the LOEC was 0.5%.

The LC50 for HSW-2 was 0.626% based upon a Trimmed Spearman-Karber method. The majority of the observed toxicity occurred in the first 24 hours. There was significant mortality at 2.0, 1.0, and 0.5% concentrations compared to the control at 96 hours. The NOEC was 0.25%, and the LOEC was 0.5%.

The reference toxicant test required the use of the Trimmed Spearman-Karber method and generated an LC50 of 4.05 mg/L, an NOEC of 3.2 mg/L, and an LOEC of 6.25 mg/L. This is the fifth reference toxicant test on *Citharichthys* at this laboratory, and the current laboratory mean is 3.95 mg/L (SD = 0.26 mg/L). The results are within one standard deviation of the laboratory mean, indicating a normally sensitive population.

3.3 *Mysidopsis bahia*

Water quality measurements were within the acceptable limits provided in EPA 1991. Temperature was maintained at 17 ± 2°C; pH remained relatively stable, and the salinity increased slightly as would be expected in a static test. The dissolved oxygen did drop as projected after test initiation in all of the concentration even with supplemental aeration and aeration was maintained in all chambers for the duration of the test. Ammonia was measured in all replicates from each concentration daily and was a potentially significant toxic component of the test for the highest three concentrations.

The LC50 for HSW-1 was 0.675%. At 96 hours, there was significant mortality at concentrations to 0.25% compared to the control. The NOEC was 0.125% and the LOEC was 0.25%.

The LC50 for HSW-2 was 0.625%. again there was significant mortality at 96 hours in the 2.0, 1.0 and 0.5% concentrations compared to the control. The NOEC was 0.25%, and the LOEC was 0.5%.

The reference toxicant test had an LC50 of 17.18 mg/L, with an NOEC of 10 mg/L and an LOEC of 20 mg/L. This is the tenth reference toxicant test on *Mysidopsis* at this laboratory, and the current laboratory mean is 14.29 mg/L (SD = 4.11 mg/L). The results are within one standard deviation of the laboratory mean, indicating a normally sensitive population.

3.4 AMMONIA MEASUREMENTS

Total ammonia in both of the HSW samples was very high. When measured in a 25% dilution in seawater, ammonia levels ranged from 55 to 95 mg/L. When converted to the 100% concentration, the ammonia level would be from 220 - 380 mg/L. The measured amount of total ammonia in the 2.0% concentrations on Day 0 in HSW-1 was 6.61 mg/L, and in HSW-2, 4.3 mg/L. In the 1.0% concentrations the total values were 3.32 mg/L and 2.10 mg/L respectively. These levels would be consistent with observed toxicity.

TABLE 1

Bioassay Procedure And Organism Data
For the Acute Bioassay
Using *Citharichthys stigmaeus* (U.S. EPA 1991)

Parameter	Data
Sample Identification	
Sample ID(s)	950626-1(HSW-1), 950626-2 (HSW-2)
Date Sampled	6/23/95
Date Received at ABT	6/26/95
Volume Received	One gallon
Sample Storage Conditions	4°C in the dark
Test Species	*Citharichthys stigmaeus*
Supplier	J. Brezina and Associates
Collection location	Tomales Bay
Date Acquired	June 25, 1995
Acclimation Time	48 hours
Acclimation Water	34 ppt seawater
Acclimation Temperature	17 ± 2°C
Age group	Juveniles, 3-5 cm TL
Test Procedures	
Type; Duration	96 hour static acute, renewal at 48 hours
Test Dates	6/27/95 to 7/1/95
Control Water	Bodega Bay seawater
Test Temperature	17 ± 2°C
Test Photoperiod	16 L : 8 D
Initial Salinity	34 ± 2 ppt
Test Chamber	10 L polyethylene chamber
Animals/Replicate	10 animals/replicate
Exposure Volume	5 L
Replicates/Treatment	5
Feeding	None
Deviations from procedures	None

TABLE 2

Bioassay Procedure And Organism Data
For the Acute Bioassay
Using *Mysidopsis bahia* (U.S. EPA 1991)

Parameter	Data
Sample Identification	
Sample ID(s)	950626-1(HSW-1), 950626-2 (HSW-2)
Date Sampled	6/23/95
Date Received at ABT	6/26/95
Volume Received	One gallon
Sample Storage Conditions	4°C in the dark
Test Species	*Mysidopsis bahia*
Supplier	Aquatox, Arkansas
Date Acquired	6/27/95
Acclimation Time	None
Acclimation Water	Shipping water
Acclimation Temperature/Salinity	20 ± 2°C/30-32 ppt salinity
Age group	3-5 day old larvae
Test Procedures	
Type; Duration	Acute; static; renewal at 48 hours
Test Dates	6/27/95 to 7/1/95
Control Water	San Francisco Bay seawater
Test Temperature	17 ± 2°C
Test Photoperiod	14 L : 10 D
Salinity	34 ± 2 ppt
Test Chamber	1000 mL jars
Animals/Replicate	10 animal/replicate
Exposure Volume	500 mL
Replicates/Treatment	5
Feeding	Brine shrimp (24 hr old nauplii)
Deviations from procedures	None

TABLE 4

Summary Of Effluent Toxicity
and
Results of the Reference Toxicity Testing

Species	Sample	LC50	95% Confidence Limits
Citharichthys	HSW-1	0.3959%	0.368% -0.426%
	HSW-2	0.6262%	0.569% -0.689%
	Ref Tox (SDS)	4.057 mg/L (acceptable)	3.51-4.69 mg/L
Mysidopsis	HSW-1	0.675%	0.563% -0.764%
	HSW-2	0.625%	0.549% -0.692%
	Ref Tox (SDS)	17.18 mg/L (acceptable)	Not calculated

4.0 REFERENCES

U.S. EPA. 1991. Methods for measuring acute toxicity of effluents to freshwater and marine organisms, 4th ed. EPA 600/4-90/027, September, 1991.

APPENDIX A

ANALYTICAL DATA

APPENDIX TABLE 1

Citharichthys stigmaeus
WATER QUALITY MEASUREMENTS FOR EFFLUENT TEST
Study Dates: 6/27 - 7/1/95
HSW-1

Concentration		Day 0					Day 1					Day 2					Day 3					Day 4				
(%)	Rep	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal
Control	1	8.07	9.1		16.4	33	8.14	8.0	<0.01	15.8	34	8.15	7.3	0.14	18.0	34	8.15	8.6	0.24	17.9	34	8.18	7.6	0.31	18.3	35
	2						8.07	7.8	<0.01	15.7	34	8.08	7.2	0.13	17.9	34	8.08	8.4	0.22	17.8	34	8.13	7.6	0.31	18.3	35
	3						8.01	7.2	<0.01	15.7	34	7.98	6.6	0.14	17.9	34	7.96	7.6	0.22	17.8	34	7.97	6.8	0.32	18.2	35
	4						8.08	7.8	<0.01	15.6	34	8.09	7.2	0.14	17.8	34	8.11	8.4	0.22	17.7	34	8.12	7.5	0.32	18.2	36
	5						8.11	7.8	<0.01	15.6	34	8.12	7.2	0.14	17.9	34	8.12	8.4	0.21	17.9	34	8.14	7.5	0.31	18.3	35
0.06	1	8.03	9.0	0.25	16.3	34	7.88	7.2	0.17	15.7	34	7.99	6.8	0.21	17.9	34	7.92	7.6	0.32	18.0	34	7.96	7.0	0.45	18.4	37
	2						7.99	7.8	0.19	15.5	34	8.09	6.9	0.24	17.8	34	8.09	8.2	0.35	17.9	34	8.13	7.6	0.49	18.3	38
	3						7.95	7.8	0.17	15.6	34	8.08	7.1	0.20	17.9	34	8.03	8.2	0.33	18.2	34	8.06	7.3	0.50	18.6	37
	4						7.97	7.8	0.20	15.5	34	8.09	7.2	0.26	17.9	34	8.09	8.2	0.40	17.7	34	8.12	7.5	0.55	18.0	38
	5						7.92	7.4	0.18	15.5	34	8.04	7.2	0.22	17.8	34	8.02	8.2	0.32	17.7	34	8.05	7.4	0.48	18.0	37
0.125	1	7.99	9.1	0.48	16.2	34	7.80	6.6	0.29	15.5	34	8.02	6.8	0.30	17.8	34	8.04	8.2	0.41	17.8	34	8.06	7.4	0.61	18.6	37
	2						7.84	6.8	0.28	15.5	34	8.04	7.0	0.33	17.8	34	8.06	8.2	0.49	17.9	34	8.10	7.4	0.68	18.2	37
	3						7.80	6.6	0.28	15.6	34	8.02	7.0	0.31	17.9	34	8.04	8.2	0.45	17.9	34	8.07	7.5	0.63	18.4	36
	4						7.90	6.4	0.29	15.4	34	8.09	7.2	0.32	17.6	34	8.13	8.2	0.44	17.8	34	8.15	7.4	0.64	18.2	38
	5						7.75	5.4	0.30	15.5	34	7.96	6.6	0.32	17.9	34	7.96	8.2	0.46	18.2	34	8.02	6.9	0.65	18.6	37
0.25	1	7.90	9.0	0.94	16.2	34	7.68	6.6	0.52	15.8	34	8.06	6.8	0.48	18.0	34	8.03	8.0	0.57	18.0	34	8.09	7.4	0.84	18.4	37
	2						7.62	5.8	0.52	15.7	34	8.03	6.8	0.48	18.0	34	8.01	8.0	0.59	18.0	34	8.07	7.3	0.84	18.4	36
	3						7.54	4.8	0.51	15.8	34	7.97	6.6	0.46	18.0	34	7.96	7.8	0.55	18.0	34	8.00	7.2	0.83	18.4	38
	4						7.55	4.8	0.52	15.7	34	7.95	6.6	0.56	18.0	34	7.95	7.6	0.55	17.9	34	7.99	7.0	0.92	18.4	36
	5						7.57	6.0	0.51	15.7	34	8.01	6.8	0.47	17.9	34	7.99	7.8	0.58	18.0	34	8.05	7.0	0.82	18.4	36
0.5	1	7.83	9.0	1.80	16.2	34	7.54	4.4	1.20	15.7	34	7.90	6.0	1.00	18.0	34	—	—	—	—	—	—	—	—	—	—
	2						7.48	4.3	1.19	15.7	34	7.85	5.9	1.08	18.0	34	—	—	—	—	—	—	—	—	—	—
	3						7.45	4.4	1.22	15.6	34	7.88	6.0	1.02	17.9	34	—	—	—	—	—	—	—	—	—	—
	4						7.52	4.1	1.18	15.7	34	7.86	5.6	1.02	18.0	34	—	—	—	—	—	—	—	—	—	—
	5						7.56	4.0	1.20	15.6	34	7.95	6.4	0.83	17.9	34	8.03	7.9	0.93	18.0	34	8.06	7.2	1.19	18.3	37
1	1	7.52	8.8	3.42	16.2	34	7.45	2.3	2.75	15.7	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.41	0.8	2.78	15.6	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.39	1.2	2.72	15.6	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.40	0.4	2.73	15.1	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.41	0.4	2.73	15.7	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	1	7.46	8.8	6.60	16.2	34	7.43	1.0	5.87	15.7	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.50	2.8	5.84	15.4	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.45	0.8	5.79	15.5	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.45	3.2	5.80	15.5	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.52	2.4	5.88	15.6	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Min		7.46	8.8	0.25	16.2	33	7.39	0.4	<0.01	15.1	34	7.85	5.6	0.13	17.6	34	7.92	7.6	0.21	17.7	34	7.96	6.8	0.31	18.0	35
Max		8.07	9.1	6.60	16.4	34	8.14	8.0	5.88	15.8	34	8.15	7.3	1.08	18.0	34	8.15	8.6	0.93	18.2	34	8.18	7.6	1.19	18.6	38

Note: — = All animals dead.

APPENDIX TABLE 1 (Cont'd)

Citharichthys stigmaeus
WATER QUALITY MEASUREMENTS FOR EFFLUENT TEST
Study Dates: 6/27 - 7/1/95
HSW-2

Concentration		Day 0					Day 1					Day 2					Day 3					Day 4				
(%)	Rep	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal	pH	DO	NH3	°C	Sal
0.06	1	8.02	9.0	0.17	16.3	34	7.98	7.6	0.20	15.5	34	8.06	7.0	0.19	17.9	34	7.99	8.2	0.34	17.8	34	8.08	7.3	0.47	18.8	37
	2						8.04	7.6	0.20	15.2	34	8.13	7.2	0.19	17.7	34	8.13	8.3	0.29	17.6	34	8.17	7.4	0.42	17.9	38
	3						8.05	7.8	0.20	15.2	34	8.14	7.3	0.19	17.7	34	8.13	8.4	0.29	17.6	34	8.15	7.6	0.41	18.0	37
	4						8.00	7.6.	0.19	15.4	34	8.06	7.1	0.19	17.9	34	8.06	8.4	0.29	17.8	34	8.07	7.3	0.41	18.2	37
	5						7.94	7.6	0.18	15.3	34	8.02	6.8	0.20	17.9	34	8.01	8.2	0.37	17.9	34	8.04	7.4	0.47	18.2	37
0.125	1	8.05	9.2	0.29	16.2	34	7.98	7.6	0.29	15.4	34	8.13	7.2	0.28	17.9	34	8.11	8.2	0.42	17.9	34	8.15	7.4	0.53	18.2	38
	2						7.93	7.5	0.19	15.4	34	8.08	7.1	0.25	18.0	34	8.07	8.4	0.36	18.0	34	8.09	7.5	0.48	18.5	37
	3						7.91	6.4	0.21	15.6	34	8.09	7.2	0.25	18.3	34	8.07	8.2	0.34	18.2	34	8.10	7.4	0.45	18.6	37
	4						7.78	7.4	0.22	15.5	34	7.99	6.6	0.25	18.1	34	7.94	7.6	0.35	18.0	34	7.94	6.6	0.45	18.3	37
	5						7.88	4.5	0.22	15.5	34	8.06	7.0	0.23	18.0	34	8.04	8.2	0.34	18.0	34	8.08	7.3	0.43	18.3	36
0.25	1	7.98	9.1	0.62	16.2	34	7.74	4.8	0.38	15.5	34	8.01	6.6	0.37	18.0	34	7.94	8.2	0.52	18.0	34	8.03	7.1	0.64	18.2	36
	2						7.78	5.8	0.38	15.3	34	8.07	7.0	0.34	18.0	34	8.03	8.0	0.48	17.9	34	8.11	7.2	0.58	18.2	37
	3						7.77	5.8	0.36	•15.3	34	8.05	7.0	0.35	18.0	34	8.01	8.2	0.49	17.9	34	8.06	7.2	0.60	18.2	37
	4						7.77	5.9	0.37	15.2	34	8.06	6.7	0.38	17.9	34	8.02	8.0	0.56	17.7	34	8.10	7.1	0.70	18.0	37
	5						7.83	6.6	0.38	15.2	34	8.10	7.0	0.36	17.8	34	8.07	8.2	0.55	17.6	34	8.14	7.5	0.62	17.9	37
0.5	1	7.91	9.0	1.18	16.0	34	7.79	5.6	0.78	15.2	34	8.09	7.0	0.58	17.9	34	8.07	8.2	0.74	17.7	34	8.13	7.5	0.89	18.0	38
	2						7.78	6.0	0.79	15.0	34	8.11	7.1	0.58	17.6	34	8.09	8.4	0.72	17.9	34	8.15	7.5	0.88	18.2	38
	3						7.59	6.0	0.84	15.5	34	8.06	7.0	0.61	18.1	34	8.08	8.2	0.74	18.0	34	8.12	7.4	0.88	18.3	36
	4						7.69	4.9	0.82	15.4	34	8.05	6.8	0.64	18.2	34	8.05	8.0	0.77	18.0	34	8.12	7.2	0.99	18.2	37
	5						7.73	5.3	0.81	15.3	34	8.09	6.8	0.57	18.2	34	8.07	8.0	0.75	18.0	34	8.14	7.2	0.86	18.3	37
1	1	7.63	9.0	2.21	16.0	34	7.64	1.0	1.39	15.4	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.59	1.1	1.37	15.5	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.52	0.8	1.79	15.5	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.48	0.6	1.70	15.4	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.47	1.0	1.71	15.4	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2.0	1	7.42	8.6	4.33	16.0	34	7.44	0.6	3.60	15.4	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.43	0.6	3.54	15.3	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.45	0.4	3.39	15.2	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.44	0.6	3.25	15.0	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.47	0.6	3.35	15.1	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Min		7.42	8.6	0.17	16.0	34	7.43	0.4	0.18	15.0	34	7.99	6.6	0.19	17.6	34	7.94	7.6	<0.10	17.6	34	7.94	6.6	0.41	17.9	36
Max		8.05	9.2	4.33	16.3	34	8.05	7.8	3.60	15.6	34	8.14	7.3	0.64	18.3	34	8.13	8.4	0.77	18.2	34	8.17	7.6	0.99	18.8	38

Note: — = All animals dead.

APPENDIX TABLE 2

Citharichthys stigmaeus
SURVIVAL DATA FOR EFFLUENT TEST
HSW-1

Concentration (%)	Rep	Initial Added	Day 1	Day 2	Day 3	Day 4	% Survival	Average % Survival
Control	1	10	10	9	9	9	90	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	98.0
0.06	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	9	90	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	98.0
0.125	1	10	10	10	10	10	100	
	2	10	10	10	9	9	90	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	98.0
0.25	1	10	10	10	10	10	100	
	2	10	9	9	9	9	90	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	98.0
0.5	1	10	9	0	—	—	0	
	2	10	10	0	—	—	0	
	3	10	8	0	—	—	0	
	4	10	10	0	—	—	0	
	5	10	8	8	8	8	80	16.0
1	1	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0
2	1	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0

Note: — = All animals dead.

APPENDIX TABLE 2 (Cont'd)

Citharichthys stigmaeus
SURVIVAL DATA FOR EFFLUENT TEST
HSW-2

Concentration (%)	Rep	Initial Added	Day 1	Day 2	Day 3	Day 4	% Survival	Average % Survival
0.06	**1**	10	10	10	9	9	90	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	9	90	96.0
0.125	**1**	10	10	10	10	9	90	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	9	90	
	5	10	9	9	9	8	80	92.0
0.25	**1**	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	9	9	8	80	
	4	10	9	9	9	8	80	
	5	10	9	9	9	9	90	90.0
0.5	**1**	10	10	10	10	8	80	
	2	10	10	10	10	10	100	
	3	10	10	9	9	9	90	
	4	10	10	10	10	10	100	
	5	10	9	9	9	9	90	92.0
1	**1**	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0
2	**1**	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0

Note: — = All animals dead.

APPENDIX TABLE 5

Mysidopsis bahia
WATER QUALITY MEASUREMENTS FOR EFFLUENT TEST
Study Dates: 6/27 - 7/1/95
HSW-1

Concentration (%)	Rep	Day 0 pH	Day 0 DO	Day 0 NH3	Day 0 °C	Day 0 Sal	Day 1 pH	Day 1 DO	Day 1 NH3	Day 1 °C	Day 1 Sal	Day 2 pH	Day 2 DO	Day 2 NH3	Day 2 °C	Day 2 Sal	Day 3 pH	Day 3 DO	Day 3 NH3	Day 3 °C	Day 3 Sal	Day 4 pH	Day 4 DO	Day 4 NH3	Day 4 °C	Day 4 Sal
Control	1	8.07	9.0		17.1	34	8.11	8.0	<0.01	16.5	34	8.25	7.4		18.2	34	8.17	8.4		18.0	34	8.20	7.7		18.3	36
	2						8.14	8.0		16.3	34	8.23	7.4	0.02	18.3	34	8.18	8.6		18.0	34	8.20	7.7		18.4	36
	3						8.13	8.0		16.3	34	8.17	7.4		18.3	34	8.09	8.6	0.03	18.1	34	8.13	7.7		18.4	35
	4						8.14	8.0		16.4	34	8.22	7.4		18.3	34	8.24	8.6		18.1	34	8.20	7.6	0.06	18.5	35
	5						8.16	8.0		16.4	34	8.24	7.4		18.2	34	8.28	8.6		18.0	34	8.26	7.7		18.3	36
0.06	1	8.02	9.0	0.25	17.9	34	7.98	7.8	0.11	16.2	34	8.10	7.2		18.3	34	8.14	8.6		18.0	34	8.11	7.4		18.4	35
	2						8.06	7.8		16.1	34	8.17	7.2	0.08	18.2	34	8.18	8.6		18.0	34	8.15	7.6		18.2	36
	3						8.04	7.8		16.0	34	8.13	7.2		18.2	34	8.12	8.6	0.11	17.9	34	8.11	7.5		18.2	35
	4						8.06	7.8		16.1	34	8.18	7.2		18.2	34	8.17	8.6		17.9	34	8.15	7.5	0.14	18.2	36
	5						8.12	8.0		16.1	34	8.22	7.3		18.2	34	8.22	8.7		17.9	34	8.20	7.6		18.2	36
0.125	1	7.96	8.8	0.48	18.0	34	7.78	6.2	0.22	16.2	34	8.16	7.2		18.2	34	8.13	8.6		18.0	34	8.13	7.6		18.4	35
	2						7.73	6.2		16.2	34	7.95	5.9	0.15	18.2	34	7.90	8.6		17.9	34	8.00	6.6		18.2	35
	3						7.98	7.8		16.1	34	8.10	7.0		18.1	34	8.14	8.4	0.22	17.9	34	8.10	7.5		18.2	35
	4						8.02	7.8		16.0	34	8.18	7.2		18.2	34	8.18	8.6		17.8	34	8.17	7.5	0.26	18.2	35
	5						7.94	7.6		16.2	34	8.14	7.2		18.3	34	8.16	8.6		17.9	34	8.14	7.6		18.3	35
0.25	1	7.90	8.8	0.94	18.0	34	7.75	7.1	0.41	16.2	34	8.04	7.0		18.2	34	8.10	8.5		18.0	34	8.08	7.5		18.4	35
	2						7.82	7.5		16.2	34	8.10	7.0	0.32	18.2	34	8.14	8.4		17.9	34	8.11	7.4		18.2	35
	3						7.86	7.4		16.1	34	8.13	7.2		18.1	34	8.13	8.6	0.47	17.8	34	8.12	7.4		18.2	35
	4						7.95	7.6		16.1	34	8.20	7.4		18.2	34	8.22	8.6		17.7	34	8.20	7.5	0.51	18.2	35
	5						7.90	7.4		16.2	34	8.12	7.2		18.3	34	8.14	8.6		17.9	34	8.14	7.6		18.3	35
0.5	1	7.92	8.8	1.80	17.9	34	7.80	6.9	0.81	16.3	34	8.20	7.2		18.2	34	8.25	8.6		18.0	34	8.23	7.4		18.4	35
	2						7.82	7.3		16.2	34	8.22	7.2	0.63	18.0	34	8.28	8.6		17.9	34	8.23	7.3		18.3	35
	3						7.74	6.2		16.2	34	8.17	7.1		18.0	34	8.23	8.6	0.83	17.9	34	8.26	7.4		18.2	35
	4						7.66	5.5		16.1	34	8.20	7.2		18.2	34	8.26	8.6		17.9	34	8.21	7.4	0.93	18.3	35
	5						7.71	6.2		16.2	34	8.20	7.2		18.3	34	8.30	8.6		17.9	34	8.25	7.4		18.3	36
1	1	7.74	8.6	3.41	17.9	34	7.64	2.8	1.91	16.3	34	8.12	6.6		18.4	34	—	—		—	—	—	—		—	—
	2						7.64	3.4		16.2	34	8.14	6.6	1.32	18.4	34	8.23	8.6		18.2	34	8.24	7.3		18.5	35
	3						7.65	3.6		16.2	34	8.15	6.7		18.3	34	8.26	8.6	1.54	18.0	34	8.29	7.4		18.4	35
	4						7.63	3.2		16.3	34	8.11	6.6		18.4	34	—	—		—	—	—	—		—	—
	5						7.64	3.6		16.2	34	8.13	6.6		18.5	34	8.29	8.6		18.1	34	8.31	7.3	1.61	18.4	35
2.0	1	7.63	8.8	6.60	17.6	34	7.46	1.2	3.51	16.5	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2						7.44	1.0		16.3	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3						7.45	2.0		16.2	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4						7.50	2.7		16.2	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5						7.46	0.6		16.4	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Min		7.63	8.6	0.25	17.1	34	7.44	0.6	<0.01	16.0	34	7.95	5.9	0.02	18.0	34	7.90	8.4	0.03	17.7	34	8.00	6.6	0.06	18.2	35
Max		8.07	9.0	6.60	18.0	34	8.16	8.0	3.51	16.5	34	8.25	7.4	1.32	18.5	34	8.30	8.7	1.54	18.2	34	8.31	7.7	1.61	18.5	36

Note: — = All animals dead.

APPENDIX TABLE 5 (Cont'd)

Mysidopsis bahia
WATER QUALITY MEASUREMENTS FOR EFFLUENT TEST
Study Dates: 6/27 - 7/1/95
HSW-2

Concentration (%)	Rep	Day 0 pH	Day 0 DO	Day 0 NH3	Day 0 °C	Day 0 Sal	Day 1 pH	Day 1 DO	Day 1 NH3	Day 1 °C	Day 1 Sal	Day 2 pH	Day 2 DO	Day 2 NH3	Day 2 °C	Day 2 Sal	Day 3 pH	Day 3 DO	Day 3 NH3	Day 3 °C	Day 3 Sal	Day 4 pH	Day 4 DO	Day 4 NH3	Day 4 °C	Day 4 Sal
0.06	1	8.01	9.0	0.17	18.6	34	8.07	7.8	0.19	16.5	34	8.22	7.1		18.4	34	8.18	8.4		18.0	34	8.22	7.7		18.5	35
	2						8.07	7.6		16.4	34	8.18	7.2	0.09	18.4	34	8.15	8.6		18.0	34	8.16	7.6		18.4	35
	3						8.10	7.8		16.4	34	8.20	7.3		18.4	34	8.18	8.6	0.12	17.9	34	8.18	7.6		18.3	35
	4						8.12	7.8		16.3	34	8.22	7.4		18.3	34	8.20	8.6		17.9	34	8.20	7.7	0.15	18.2	35
	5						8.16	7.8		16.3	34	8.24	7.4		18.3	34	8.22	8.6		18.0	34	8.23	7.7		18.3	35
0.125	1	8.02	9.0	0.29	18.6	34	8.12	7.8	0.20	16.4	34	8.23	7.4		18.4	34	8.20	8.6		17.9	34	8.22	7.7		18.4	35
	2						8.14	7.8		16.4	34	8.25	7.3	0.12	18.3	34	8.20	8.6		17.9	34	8.25	7.8		18.3	35
	3						8.05	7.6		16.3	34	8.18	7.2		18.3	34	8.13	8.6	0.18	17.9	34	8.16	7.6		18.2	35
	4						8.09	7.8		16.2	34	8.20	7.3		18.2	34	8.20	8.6		17.9	34	8.22	7.6	0.20	18.2	35
	5						8.12	7.8		16.2	34	8.24	7.4		18.2	34	8.21	8.6		17.9	34	8.23	7.6		18.2	35
0.25	1	7.97	9.0	0.62	18.6	34	7.93	7.0	0.36	16.4	34	8.16	7.2		18.4	34	8.11	8.4		17.9	34	8.18	7.6		18.4	35
	2						7.92	7.4		16.3	34	8.17	7.2	0.25	18.3	34	8.14	8.4		17.9	34	8.22	7.6		18.2	35
	3						7.92	7.3		16.2	34	8.18	7.2		18.3	34	8.12	8.4	0.36	17.9	34	8.21	7.6		18.2	35
	4						8.02	7.4		16.2	34	8.22	7.4		18.2	34	8.12	8.5		17.9	34	8.25	7.6	0.41	18.2	35
	5						8.01	7.6		16.2	34	8.24	7.4		18.2	34	8.21	8.6		17.9	34	8.25	7.7		18.2	35
0.5	1	7.94	9.0	1.18	18.6	34	7.93	6.8	0.62	16.4	34	8.26	7.3		18.3	34	8.22	8.6		17.9	34	8.27	7.6		18.3	36
	2						7.90	6.4		16.3	34	8.25	7.3	0.51	18.3	34	8.20	8.4		17.9	34	8.27	7.6		18.2	35
	3						7.86	6.1		16.2	34	8.22	7.2		18.3	34	8.20	8.6	0.64	17.9	34	8.26	7.5		18.2	35
	4						7.80	4.8		16.3	34	8.22	7.2		18.2	34	8.18	8.5		17.9	34	8.26	7.6	0.73	18.2	35
	5						7.75	4.7		16.2	34	8.18	7.2		18.2	34	8.04	8.4		17.9	34	8.17	7.6		18.2	35
1	1	7.84	8.8	2.21	18.6	34	7.77	6.4	1.33	16.4	34	8.23	7.2		18.3	34	8.27	7.9		17.9	34	8.28	7.4		18.3	35
	2						7.66	5.0		16.3	34	8.15	7.0	1.06	18.3	34	8.26	8.3		17.9	34	8.27	7.4		18.3	35
	3						7.69	6.2		16.3	34	8.18	7.0		18.3	34	8.29	8.4	1.19	17.9	34	8.29	7.4		18.2	35
	4						7.70	5.4		16.2	34	8.20	7.0		18.2	34	8.26	8.6		17.9	34	8.24	7.2	1.36	18.2	35
	5						7.68	5.8		16.2	34	8.19	7.0		18.2	34	8.27	8.6		17.9	34	8.23	7.2		18.2	35
2.0	1	7.72	8.6	4.33	18.5	34	7.64	1.6	2.80	16.4	34	8.22	7.0		18.4	34	—	—	—	—	—	—	—	—	—	—
	2						7.60	0.6		16.3	34	8.16	6.1	2.26	18.3	34	—	—	—	—	—	—	—	—	—	—
	3						7.62	1.6		16.3	34	8.16	6.7		18.3	34	—	—	—	—	—	—	—	—	—	—
	4						7.58	0.4		16.3	34	8.12	6.4		18.3	34	—	—	—	—	—	—	—	—	—	—
	5						7.55	0.4		16.3	34	8.11	6.2		18.2	34	—	—	—	—	—	—	—	—	—	—
Min		7.72	8.6	0.17	18.5	34	7.55	0.4	0.19	16.2	34	8.11	6.1	0.09	18.2	34	8.04	7.9	0.12	17.9	34	8.16	7.2	0.15	18.2	35
Max		8.02	9.0	4.33	18.6	34	8.16	7.8	2.80	16.5	34	8.26	7.4	2.26	18.4	34	8.29	8.6	1.19	18.0	34	8.29	7.8	1.36	18.5	36

Note: — = All animals dead.

APPENDIX TABLE 6

Mysidopsis bahia
SURVIVAL DATA FOR EFFLUENT TEST
HSW-1

Concentration (%)	Rep	Initial Added	Day 1	Day 2	Day 3	Day 4	% Survival	Average % Survival
Control	1	10	9	9	9	9	90	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	98.0
0.06	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	100.0
0.125	1	10	9	9	9	9	90	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	10	10	100	
	5	10	9	9	9	9	90	96.0
0.25	1	10	10	*	*	7	70	
	2	10	10	*	*	10	100	
	3	10	10	*	*	8	80	
	4	10	9	*	*	6	60	
	5	10	10	*	*	10	100	82.0
0.5	1	10	*	*	*	5	50	
	2	10	*	*	*	7	70	
	3	10	*	*	*	7	70	
	4	10	*	*	*	10	100	
	5	10	*	*	*	8	80	74.0
1	1	10	*	0	—	—	0	
	2	10	*	*	*	2	20	
	3	10	*	*	*	0	0	
	4	10	*	0	—	—	0	
	5	10	*	*	*	0	0	4.0
2	1	10	0	—	—	—	0	
	2	10	0	—	—	—	0	
	3	10	0	—	—	—	0	
	4	10	0	—	—	—	0	
	5	10	0	—	—	—	0	0.0

Notes: — = All animals dead.
* Sample too turbid to do counts.

APPENDIX TABLE 6 (Cont'd)

Mysidopsis bahia
SURVIVAL DATA FOR EFFLUENT TEST
HSW-2

Concentration (%)	Rep	Initial Added	Day 1	Day 2	Day 3	Day 4	% Survival	Average % Survival
0.06	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	
	4	10	10	10	9	9	90	
	5	10	10	9	9	9	90	96.0
0.125	1	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	10	9	90	
	4	10	10	10	10	10	100	
	5	10	10	10	10	10	100	98.0
0.25	1	10	*	*	10	10	100	
	2	10	*	*	10	9	90	
	3	10	*	*	10	10	100	
	4	10	*	*	9	9	90	
	5	10	*	*	10	10	100	96.0
0.5	1	10	*	*	*	5	50	
	2	10	*	*	*	6	60	
	3	10	*	*	*	7	70	
	4	10	*	*	*	7	70	
	5	10	*	*	*	6	60	62.0
1	1	10	*	*	*	1	10	
	2	10	*	*	*	0	0	
	3	10	*	*	*	2	20	
	4	10	*	*	*	0	0	
	5	10	*	*	*	2	20	10.0
2	1	10	*	0	—	—	0	
	2	10	*	0	—	—	0	
	3	10	*	0	—	—	0	
	4	10	*	0	—	—	0	
	5	10	*	0	—	—	0	0.0

Notes: — = All animals dead.
* Sample too turbid to do counts.

APPENDIX TABLE 7

Mysidopsis bahia
WATER QUALITY MEASUREMENTS
FOR REFERENCE TOXICANT (S.D.S) TEST

Concentration (mg/L)	Rep	Day 0 pH	Day 0 DO	Day 0 °C	Day 0 Sal	Day 1 pH	Day 1 DO	Day 1 °C	Day 1 Sal	Day 2 pH	Day 2 DO	Day 2 °C	Day 2 Sal	Day 3 pH	Day 3 DO	Day 3 °C	Day 3 Sal	Day 4 pH	Day 4 DO	Day 4 °C	Day 4 Sal
0.7	**1**	8.07	9.0	17.5	34	8.11	7.8	16.5	34	8.09	6.8	18.6	34	7.98	7.8	18.4	34	7.77	6.3	18.7	35
	2					8.10	7.8	16.3	34	8.08	6.8	18.5	34	8.00	8.0	18.2	34	7.82	6.5	18.6	35
	3					8.10	7.7	16.2	34	8.07	6.6	18.4	34	8.00	8.0	18.0	34	7.84	6.4	18.5	35
1.25	**1**	8.08	9.0	17.6	34	8.07	7.3	16.4	34	8.04	6.4	18.5	34	7.97	8.0	18.2	34	7.84	6.5	18.6	35
	2					8.08	7.3	16.4	34	8.05	6.6	18.5	34	7.98	7.8	18.2	34	7.85	6.4	18.6	35
	3					8.08	7.3	16.2	34	8.06	6.6	18.4	34	7.98	7.8	18.1	34	7.85	6.4	18.6	35
2.5	**1**	8.08	9.2	17.6	34	8.05	7.0	16.4	34	8.03	6.6	18.5	34	7.96	7.8	18.2	34	7.86	6.2	18.5	35
	2					8.04	6.8	16.3	34	8.03	6.6	18.5	34	7.97	7.8	18.1	34	7.87	6.3	18.5	35
	3					8.04	6.8	16.2	34	8.04	6.6	18.5	34	7.98	7.8	18.1	34	7.87	6.3	18.5	35
5	**1**	8.08	9.2	17.6	34	7.99	6.0	16.5	34	7.96	6.0	18.5	34	7.89	7.0	18.2	34	7.84	5.8	18.6	35
	2					7.98	5.8	16.4	34	7.96	6.0	18.5	34	7.90	7.1	18.1	34	7.80	5.7	18.5	35
	3					7.98	5.8	16.2	34	7.98	6.2	18.5	34	7.92	7.3	18.1	34	7.81	5.8	18.5	35
10	**1**	8.08	9.2	17.6	34	7.93	5.0	16.5	34	7.87	5.2	18.6	34	7.87	7.3	18.2	34	7.82	6.0	18.6	35
	2					7.92	5.1	16.3	34	7.83	5.2	18.5	34	7.86	7.3	18.1	34	7.85	6.3	18.5	35
	3					7.92	4.9	16.2	34	7.83	5.1	18.5	34	7.87	7.4	18.1	34	7.86	6.5	18.5	34
20	**1**	8.09	9.2	17.6	34	7.92	4.9	16.4	34	7.73	4.8	18.6	34	7.75	5.8	18.3	34	7.79	6.1	18.6	34
	2					7.93	4.9	16.4	34	7.69	4.7	18.5	34	7.70	5.3	18.2	34	7.75	6.1	18.6	34
	3					7.93	5.0	16.2	34	7.68	4.8	18.5	34	7.68	5.1	18.2	34	7.74	6.0	18.5	34
Min		8.07	9.0	17.5	34	7.92	4.9	16.2	34	7.68	4.7	18.4	34	7.68	5.1	18.0	34	7.74	5.7	18.5	34
Max		8.09	9.2	17.6	34	8.11	7.8	16.5	34	8.09	6.8	18.6	34	8.00	8.0	18.4	34	7.87	6.5	18.7	35

Note: — = All animals dead.

APPENDIX TABLE 8

Mysidopsis bahia

SURVIVAL DATA FOR REFERENCE TOXICANT (S.D.S.) TEST

Concentration (mg/L)	Rep	Initial Added	Day 1	Day 2	Day 3	Day 4	% Survival	Average % Survival
0.7	**1**	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	10	9	9	90	96.7
1.25	**1**	10	10	10	10	10	100	
	2	10	10	10	9	9	90	
	3	10	10	10	10	10	100	96.7
2.5	**1**	10	10	10	10	9	90	
	2	10	10	10	10	10	100	
	3	10	10	10	10	10	100	96.7
5	**1**	10	10	10	10	10	100	
	2	10	10	10	10	10	100	
	3	10	10	9	9	9	90	96.7
10	**1**	10	10	10	9	8	80	
	2	10	10	10	10	10	100	
	3	10	10	10	8	8	80	86.7
20	**1**	10	2	1	1	1	10	
	2	10	7	6	6	6	60	
	3	10	8	3	3	3	30	33.3

Note: — = All animals dead.

Appendix 8
FEIS Model Description (Appendix B of 1989 FEIS)

APPENDIX B

MATHEMATICAL MODELING

OF FISH WASTE DISPOSAL IN DEEP WATER

FINAL
ENVIRONMENTAL IMPACT STATEMENT

FOR THE DESIGNATION
OF AN OCEAN DISPOSAL SITE FOR FISH CANNERY WASTES
OFF TUTUILA ISLAND, AMERICAN SAMOA

1. INTRODUCTION

The purpose of this study is to predict the fate of fish processing wastes which are discharged at the present dumpsite off Tutuila Island, American Samoa in the South Pacific. The center point of the 1.5 nautical mile (n mi) diameter dumpsite is located at 170°40.87'W and 14°22.18'S. and is about 3.3 n mi due east of Sail Rock Point on Tutuila Island.

The preferred dumpsite selected in the FEIS is located at 170°38.30'W and 14°24.00'S, southeast of the present site. The model studies in this section were performed using the present site and known oceanographic conditions and waste characteristics, but the results are equally applicable to the preferred site under present waste loadings.

The waste is expected to undergo rapid initial mixing after discharge. Since the gross bulk density of the fish waste is between 0.72 and 0.99 gm/ml, the majority of the plume will remain near the ocean surface immediately after being discharged from the ship. Since the model developed by Koh and Chang (1973) was designed to simulate disposal of wastes that are heavier than the sea water, a new mathematical model has been formulated specifically for this study to predict the fate of the floating plume. This model can simulate the diffusion (lateral and vertical) and settling of the waste particles while the plume is advected in the direction of the ambient current. Most of the data used in the simulations were obtained from the reports published by Soule and Oguri (1983 and 1984) but subsequent monitoring data in 1987 and 1988 (See Appendix A) are consistent with the previously published data. The results of the simulations are presented in terms of dilution as a function of time after discharge, and/or distance and time from the discharge location. The simulations have been performed for two density profiles (summer and winter), three ambient currents (0.2, 0.4, and 0.8 knots), and three particle settling velocities (1, 0.1, and 0.01 cm/sec). The waste plume is advected downstream by the ambient current. The direction of the ambient current varies with the season and the time of measurement. Some drogue studies by Soule and Oguri (1984) indicate movement toward the southwest direction while some 1987 current meter data indicate movement in the northwest direction. A close examination of the current direction based on the data published in the U.S. Navy Marine Climatic Atlas of the World (1979) for the region under study also indicates a SW direction. The prevailing south equatorial current indicates the direction is from SE toward NW. In order to cover several possible scenarios several current directions are used for simulation.

Since no data were ascertained for the settling velocity of the waste particles of the Samoa plant, velocities of 1, 0.1, and 0.01 cm/sec have been used in the calculations to cover the possible range of settling velocities. It is possible to distinguish the waste particles into three categories according to the density of the particles: (a) particles that are buoyant will form a thin layer floating at the ocean surface; (b) particles that are neutrally buoyant will be mixed and dispersed within the mixed layer (the mixed layer is the surface layer of the ocean extending from the ocean surface to the thermocline); (c) particles that are heavier than sea water will sink as the layer of waste particles is advected by the ambient current.

2. DEVELOPMENT OF MATHEMATICAL MODEL

Based on the data contained in Soule and Oguri (1983), the bulk densities of the fish processing wastes generated by Star-Kist Samoa and Samoa Packing are 0.72 to 0.96 gm/ml and 0.99 gm/ml, respectively. Recent data on the specific gravity tests of the cannery waste provided to us on November 13, 1987 indicate a range of 0.99 to 1.023 gm/ml have been measured. Thus the possible settling velocity of the particulates in the plume is covered in our range of simulation. The tuna fish waste discharged from the ship is predominantly buoyant in sea water. Immediately after being discharged by the vessel pumps it undergoes rapid, near field, initial mixing similar to mixing in a jet. Because the discharge vessel circles around within the discharge zone, it is reasonable to assume that this nearfield mixing process, in combination with the ship's track and the prevailing current, would (1) establish an initial zone of width L and depth H within which the mean concentration is Co, and (2) the plume would drift downstream emanating from this initial zone. The dimension L would be expected to be approximately the turning diameter of the discharge ship. The concentration Co would correspond to the dilution obtained by the discharge jet as it is propelled downward and then returns towards the surface. The dimension H would be obtained such that where Q is the

$$U \; L \; H \; Co = Q \qquad (2.1)$$

discharge rate of the tuna fish waste and U is the magnitude of the prevailing current. It can be visualized that the initial plume to be advected by the ambient current has a concentration Co with the plume width L and the plume depth extending from the ocean surface downward by a value of H.

Each discharge episode would have a duration T. We shall assume that the prevailing current can be regarded as constant during that time. Then a plume of length UT would be generated as a result of the discharge episode.

Along the length of the plume, the concentration would decrease from

Co due to lateral mixing. Longitudinal diffusion will be probably small.

Diffusion of waste effluent in an ocean current was analyzed by Brooks (1960), taking into account the increase of the eddy diffusivity as the waste field spreads.

The basic differential equation, based on the principle of conservation of mass, for the substance being diffused is:

$$\frac{\partial}{\partial y}\left(-\varepsilon\frac{\partial C}{\partial y}\right) + U\frac{\partial C}{\partial x} + KC = 0 \qquad (2.2)$$

where the spatial coordinate x represents longitudinal direction (in the direction of ambient current) and y represents the lateral direction. The three terms in the above equation represents the rates of concentration decay per unit volume due to lateral diffusion, longitudinal advection and apparent dieoff respectively.

Incorporating an exponential decay term to take care of the dieoff term in Equation 2.2 such as

$$C = \phi e^{-Kx/U} \qquad (2.3)$$

would transform the equation into a simpler differential equation

$$\varepsilon\frac{\partial^2\phi}{\partial y} = U\frac{\partial\phi}{\partial x} \qquad (2.4)$$

The function ϕ is the concentration without any dieoff effect; it is a function of x and y.

An additional change of variable: $\varepsilon = \varepsilon_o f(x)$ and $dx' = f(x)dx$ would allow one to transform Equation 2.4 to the classical heat equation as follows:

$$\varepsilon\frac{\partial^2\phi}{\partial y^2} = U\frac{\partial\phi}{\partial x} \qquad (2.5)$$

where ε_o is the eddy diffusivity at x=0.

An exact solution to Equation 2.5, therefore, Equation 2.2 can easily be found as:

$$C(x,y) = \frac{Co\ e^{-Kx/U}}{2\sqrt{\pi \mathcal{E}_o t'}} \int_{-\frac{b}{2}}^{\frac{b}{2}} e^{-\frac{(y-y')^2}{4\mathcal{E}_o t'}} dy \qquad (2.6)$$

in which $t' = x'/U$ has been used, Co is the initial waste concentration at $x=0$, for $-b/2 < y < b/2$.

The integral in Equation 2.6 can be arranged to become the well known error function defined as

$$\text{erf } z = (2/\sqrt{\pi}) \int_0^z \exp(-\xi^2)\ d\xi \qquad (2.7)$$

We further introduce the concentration Cmax(x) as the concentration of the waste plume at y=0 and neglect the dieoff effect (i.e. set k=0.), this would yield a conservative estimation. We also assume that the lateral diffusivity can be expressed as

$$\mathcal{E} = A\ L^{4/3} \qquad (2.8)$$

where L is a length parameter proportional to the lateral width of the plume and A is a proportionality constant.

Thus, the maximum concentration at the center line of the plume can be simplified to be

$$\frac{Cmax}{Co} = \text{erf}\{ [\frac{1.5}{(1 + 8\ A\ t\ /\ L^{2/3})^3 - 1}]^{1/2} \} \qquad (2.9)$$

The error function in Equation 2.9 has been defined in Equation 2.7, and t is defined as x/U with x denoting the distance downstream from the initial dumping location.

For the waste with settling velocity Ws, it can be readily visualized that the combination of lateral diffusion, downstream advection by current, and settling can be schematised to a very good approximation by taking an x' coordinate inclined to the original downstream x coordinate by an angle $\theta = \tan^{-1}(Ws/U)$, as shown in Figure 2-1.

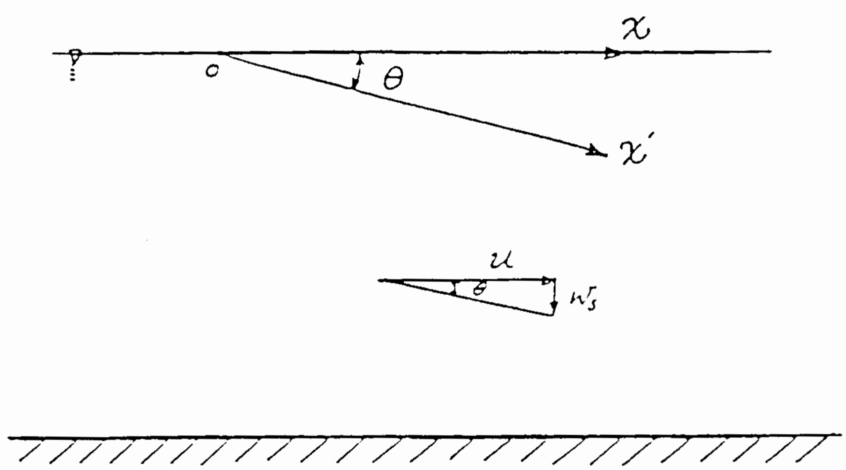

Figure 2-1. Definition sketch of the longitudinal direction with the effects of settling velocity.

Physically we are simply following the particles down with a velocity Ws while they are being advected downstream at speed U. The reduction in concentration still obeys the same formula as in Equation 2.9 except that the velocity along x' should be $U' = \sqrt{(U^2 + Ws^2)}$. But $t = x/U = x'/U'$ and hence the evaluation of Equation 2.9 needs only to be performed once for all Ws. Only the vertical location needs to be changed for each of the particle classes with differing fall velocities.

The effect of vertical diffusion can be incorporated approximately by deducing a concentration reduction factor based on vertical diffusion. For this purpose we assume Fickian diffusion with a diffusion coefficient Kv. Then it can be readily deduced that the concentration reduction factor due to vertical diffusion is approximately

$$\frac{H/4}{(2\ Kv\ t + H^2/16)^{1/2}} \qquad (2.10)$$

The quantity in the denominater is simply the characteristic vertical dimension (standard deviation) of the plume whose initial dimension is H/4. Combining this with the reduction due to lateral diffusion gives

$$\frac{Cmax}{Co} = \frac{H/4}{(2Kvt+H^2/16)^{1/2}}\ \mathrm{erf}\{\ [\ \frac{1.5}{(1 + 8At/L^{2/3})^3 - 1}\ ]^{1/2}\ \} \qquad (2.11)$$

where the vertical location of the centroid y is

$$y = Ws\ t = Ws\ x\ /\ U \qquad (2.12)$$

The above formulation retains all the essence of the complicated diffusion process in an ocean current. It is believed that this model provides a good and valid estimate of the mixing, transport, and diffusion of the tuna fish waste.

3. RESULTS OF MATHEMATICAL MODELING

The mathematical model developed in Section 2 was used to simulate the fate of the discharged fish processing wastes with the available data. The data used in the simulations are first presented. Then the results are presented in terms of dilution as a function of time after discharge and distance from the discharge location. According to Fischer et al. (1979), dilution usually is defined as the ratio of the total volume of a sample to the volume of effluent contained in the sample. Thus the volume fraction of effluent in a sample is equal to the reciprocal of dilution.

3.1 Data used for Simulations

The following input data are obtained from Soule and Oguri (1983):

Ambient Current Velocity	0 to 0.8 knots	
Ambient Density Profiles	summer, winter	
Dumpsite Water Depth	1.46 km (800 fathoms)	
Discharge Rate	500 to 1400 gpm	
	(1.89 cu m/min to 5.30 cu m/min)	
Sludge Bulk Density	0.72 to 0.96 gm/ml	Star-Kist
	0.99 gm/ml	Van Camp
Sludge Tank Capacity	24000 gal (90.85 cu m)	
Dump Vessel Key Dimensions	Length = 49.0 m Beam = 8.1 m Draft = 3.35 m	

The radius of the dumping circle circumscribed by the dump vessel is 0.2 n mi. Also, the pumping rate of the sludge is 140 gpm per knot of vessel speed which can go up to 10 knots. Thus, for our simulation a range of discharge rates between 500 gpm and 1400 gpm is used. The discharge of the fish waste is completed within a time period during which the current direction does not change. For example, with the sludge tank capacity of 24,000 gallons and the discharge rate of 500 gpm the estimated discharge period would be 48 minutes. It is reasonable to assume that the direction of the current would not be altered during this period.

Data of the ambient current velocity in the vicinity of the dumpsite are also available from the drogue and waste plume tracking studies conducted by Soule and Oguri (1984) and 1987 permit monitoring data. According to the drogue tracking studies, the speed of the surface current ranges from 0.39 to 0.94 knots. The waste plume was observed to move at an average speed of 0.67 knots. These values of the ambient current speed are in good agreement with the values (0.4 to 0.8 knots) published in the U.S. Navy Marine Climatic Atlas of the World (1979). The prevailing surface current patterns in the South Pacific Ocean for the summer and winter seasons are shown in Figures 3-1 and 3-2, respectively. Therefore, current speeds of 0.2, 0.4, and 0.8 knots have been used in the simulations.

Two ambient density profiles have been used in the simulations to account for the summer and winter seasons. Typical sea water temperature and salinity profiles for the summer and winter seasons are shown in Tables 3-1 and 3-2, respectively. These profiles were obtained from Soule and Oguri (1983) who conducted cruise studies in the vicinity of the dumpsite. As shown in Table 3-1, the temperature data were obtained to a water depth of 24.5 m. However, a thermocline would be present in the summer season. Hence, a thermocline is assumed to be present at a water depth of about 100 - 200 m based on the data available for the Southern Pacific Ocean. The sea water temperature profile for the summer season looks like this:

0 to 100 m	same as shown in Table 3-1
100 to 200 m	a temperature gradient of $8^{o}C$ / 50 m
below 200 m	a temperature gradient of $1.2^{o}C$ / 50 m

FIG. 3-1 PREVAILING SURFACE CURRENTS SUMMER, (DEC., JAN., FEB.)

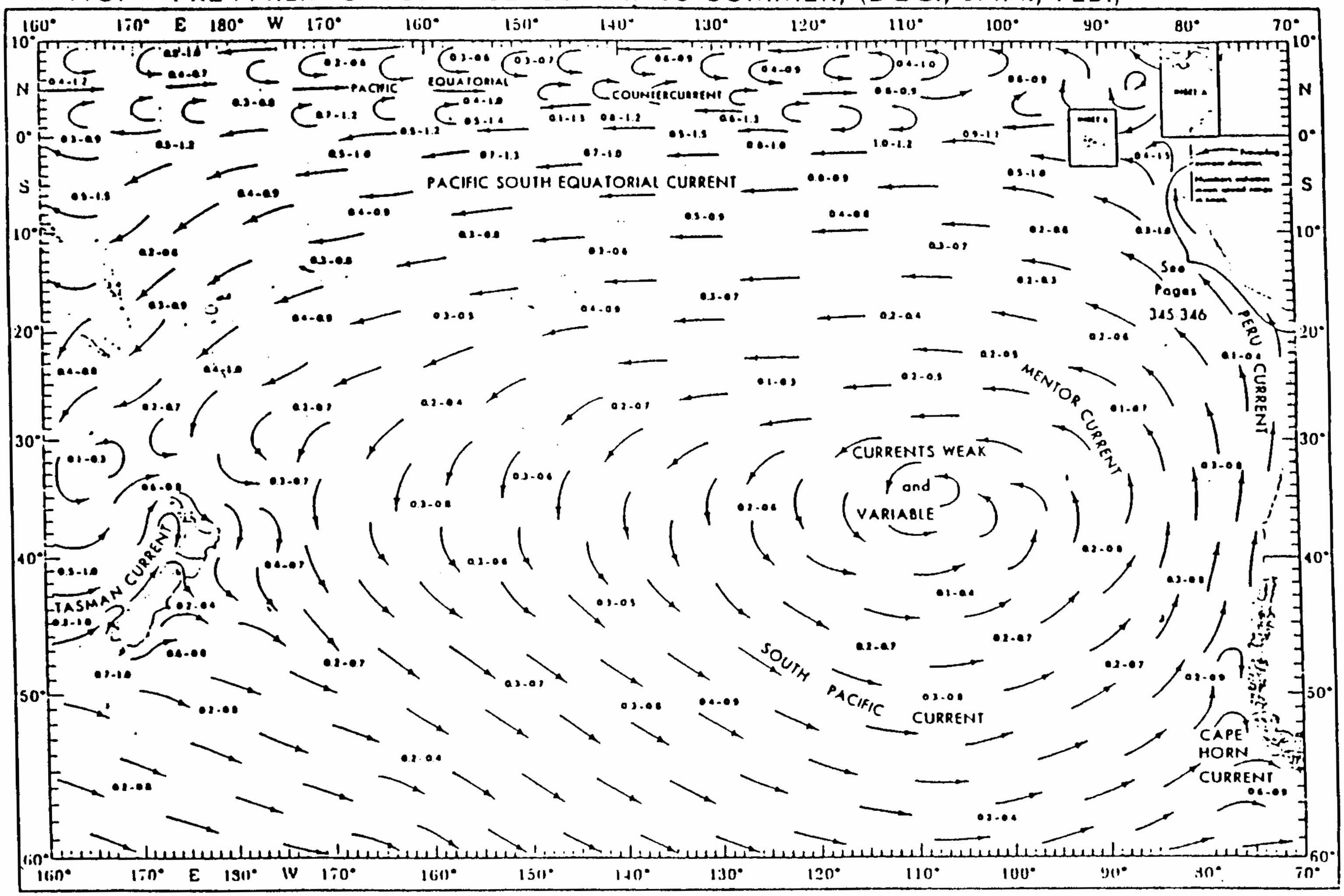

FIG. 3-2 PREVAILING SURFACE CURRENTS WINTER, (JUN., JUL., AUG.)

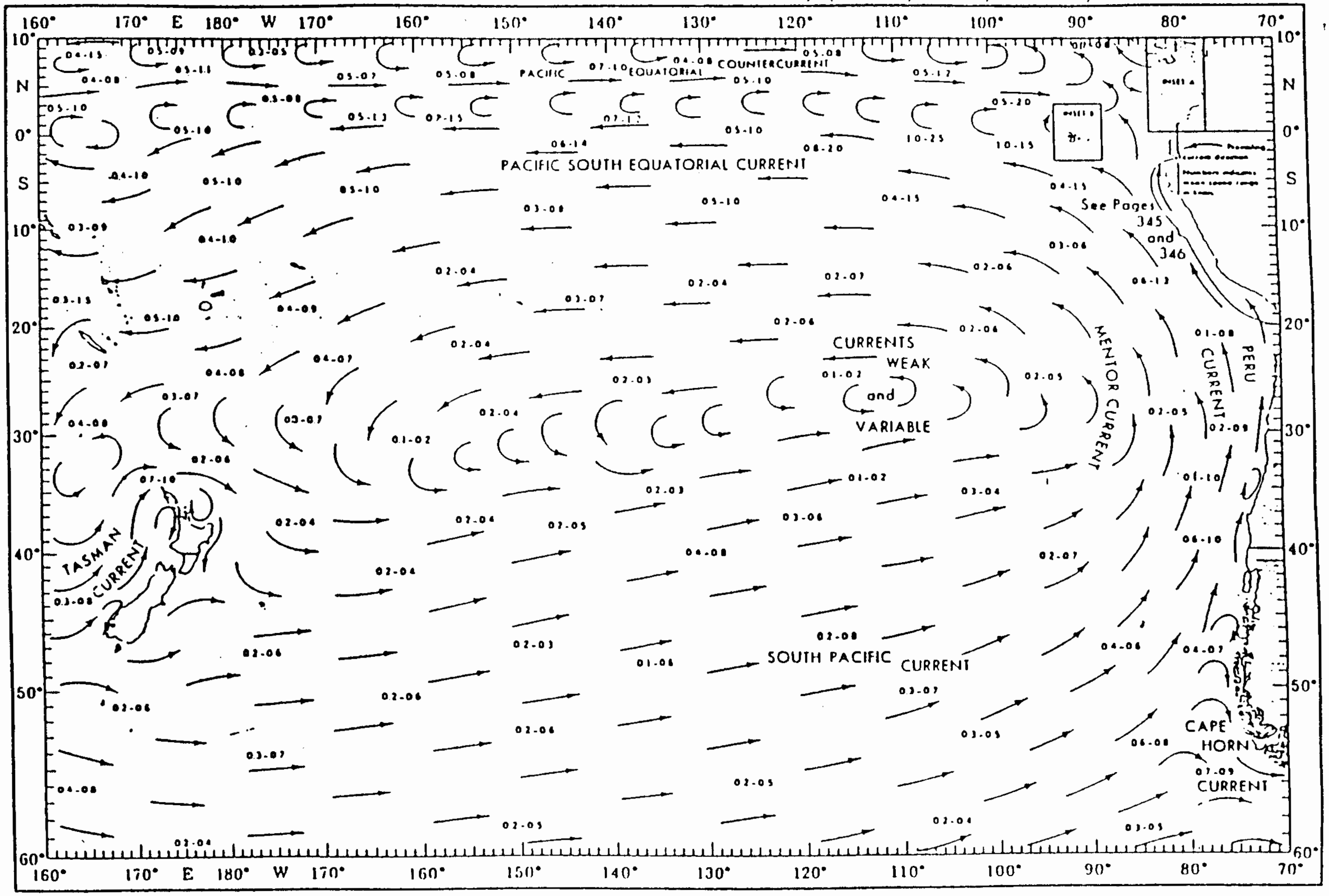

Table 3-1

CRUISE: Star-Kist - Van Camp NOAA-OMPA-AMERICAN SAMOA

VESSEL: AUTELE

DATE: 21 Jan. 1982

WEATHER: See Cruise Report

SEA STATE: See Cruise Report

TIDE: High: 1710, 2.6ft.

Station	Depth m	Time	Temp °C	Sal o/oo	DO mg/l	pH	%T	Secchi m	FU	NH_3 µg-at/l	BOD mg/l	TOC mg/l	DO Winkler
TP05	0	1045	29.8	36.3	5.9	8.4	55	3	6		4.5		5.4
	3		29.9	36.8	6.1	8.4	85				3.5		5.4
	6		29.5	37.0	6.1	8.4	90						5.6
	10		29.4	37.0	6.1	8.4	96				3		5.5
	15		29.4		6.0	8.5	98						
TS06	0	1115	29.5	36.1	5.7	8.4	87	4	4				5.4
	3		29.5	36.5	5.5	8.4	86						5.7
	6		29.4	36.5	5.8	8.4	91						5.8
	10		29.4	36.8	6.0	8.5	95						5.6
	15		29.4		5.8	8.5	96						
TS07	0	1135	29.4	36.6	5.7	8.4	90	7	3		7.5		5.6
	3		29.5	36.6	6.0	8.4	88				5		5.4
	6		29.5	36.7	5.7	8.4	91				6		5.6
	10		29.5	36.9	5.8	8.4	92				5.5		5.7
	15		29.5		5.8	8.5	94						
	20		29.4		5.8	8.5	93						
	24.5		29.4		5.8	8.5	93						

Table 3-2

CRUISE: NOAA-OMPA-Star-Kist Samoa | VESSEL: Autele | DATE: 23 July 1982

WEATHER: Hot, calm with gusts, 2-6k | SEA STATE: Long swells, 8-10ft | TIDE: Low 1530, -0.5ft

Station (Map/Site)	Depth m	Time	Temp °C	Sal o/oo	DO mg/l	pH	ΔT	Secchi m	FU	NH_3 µg-at/l	BOD mg/l	TOC mg/l
TS E (6)	0	1141	28.37	34.28	6.68	8.27		3	6			
	3		28.33	34.30	6.64	8.26						
	6		28.25	34.32	6.68	8.26						
	10		28.24	34.32	6.65	8.26						
	15		28.24	34.33	6.66	8.27						
	20		28.23	34.35	6.63	8.27						
* (7)												
TS F (8)	0	1157	28.59	34.25	6.62	8.25		4	4			
	3		28.29	34.31	6.66	8.26						
	6		28.26	34.31	6.41	8.26						
	10		28.25	34.32	6.41	8.27						
	15		28.25	34.32	6.51	8.27						
	20		28.25	34.32	6.41	8.27						
TS G (9)	0	1206	28.44	34.27	6.62	8.25		14	3			
	3		28.31	34.30	6.65	8.26						
	6		28.26	34.30	6.66	8.27						
	10		28.24	34.31	6.53	8.27						
	15		28.24	24.32	6.42	8.27						
	20		28.24	34.31	6.41	8.27						

*7 1151 drogues only

For water depths below 100 m, the temperature gradients have been estimated from the data shown in Figure III.11, of this volume. A temperature profile as shown in Table 3-2 has been assumed for the winter season. The temperature gradient is about 0.5^{o}C per 30.5m.

3.2 Results of Simulations

Before the simulations were performed, parameters such as A, Co, Kv, and L in Equation 2.11 need to be calculated or chosen. The parameter A is a constant called the dissipation parameter. The constant A relates the lateral diffusivity to the plume width parameter as defined in Equation 2.8. The empirical value of A in the ocean environment is generally from 0.1 to 0.0001 ft$^{2/3}$ /sec. (See Koh & Fan 1970, page 129 for presentation of such data). For the study site the exact value of A is not known. Therefore, a median value in the range just cited can be assumed. The value of A chosen for this simulation is 0.001 ft$^{2/3}$ /sec Since the exact value varies from day to day and it also depends on the currents in the study site, this chosen value is believed to be reasonable. More precise value may be obtained by field experiments.

The initial mean concentration Co of the fish wastes discharged into the ocean water through the disposal ship must be estimated based on the discharge rate. This value corresponds to the dilution obtained at the wake of the discharge ship and it can be estimated by the formula developed by Koh and Chang (1973). In their analysis they first assumed that the pumping rate of the waste material is such that the waste material is completely mixed into the wake by the turbulence without altering the wake flow pattern. Secondly, the effect of surface waves can be disregarded so that the flow pattern can be approximated from the analysis of the jet and wake flows. Thirdly, they assumed that the flow pattern approaches a similarity form at a certain distance from the discharge point. Based on the given information of the discharge vessel and the assumptions involved in deriving the Koh and Chang formula, the initial mean concentration, Co, can be estimated by the following formula:

$$Co = \frac{Q}{1.814 \pi R^2 V} \tag{3.1}$$

where Q is the discharge rate of the fish waste from the discharge pipe.

R is a characteristic length of the body which is chosen as the geometric mean of the half beam and the draft of the discharge vessel (i.e. [(ship draft) (half beam)]$^{1/2}$.

V is the relative velocity between ship and ambient current.

It should be noted that based on Equation 3.1 the scale of the mixing zone in the wake is proportional to the characteristic dimension of the discharge vessel which is reasonable.

The vertical diffusion coefficient Kv can be evaluated by the formulation of Koh and Fan (1970)

$$Kv = 10^{-4} / E \qquad \text{(sq cm/sec)} \tag{3.2}$$

and

$$E = \left| \frac{1}{\rho} \frac{d}{dy} \right| \tag{3.3}$$

where E = sea water density gradient

ρ = sea water density

y = water depth (meters)

From the temperature profiles developed in Section 3.1, the values of Kv, as shown in Table 3-3, are calculated as a function of water depth for the summer and winter seasons.

The width L of the initial plume is expected to be approximately twice the turning radius of the discharge ship. Since the turning radius

Table 3-3. Vertical Diffusion Coefficient.

Depth (m)	Kv (sq cm/sec) Summer	Winter
0 - 100	7.8	17.3
100 - 200	1.2	17.3
> 200	7.3	17.3

of the disposal vessel is 0.2 n mi (370.5 m), L is taken to be 741 m.

The results of the simulations are presented in terms of dilution of the fish wastes as a function of time after discharge and distance from the discharge location. Dilution is reciprocal of the product of Co and Cmax/Co. This value gives an indication of the volume fraction of fish waste in the water sample after the waste plume has traveled for a certain distance from the discharge location. Since no data have been obtained for the settling velocity of the Samoa waste particles, velocities of 1, 0.1, and 0.01 cm/sec have been used in the calculations to cover the possible range of settling velocities which is a function of the density of the waste material relative to the sea water density. The group of results with settling velocities of 0.01, 0.1, and 1.0 cm/sec would correspond to the particles that are floating on the ocean surface, neutrally buoyant in sea water and heavier than sea water respectively. The behavior of the particles with a settling velocity of 0.1 cm/sec is similar to that of neutrally buoyant particles and thus they are advected by the ambient surface and near surface currents.

The settling tank experiments reported by Soule and Oguri (1983) indicate that 30% of the fish waste being studied had a fall velocity greater than zero, 7% of the wastes had a fall velocity greater than 0.059 cm/sec and only 0.5% of the waste had a fall velocity greater than 0.24 cm/sec. Therefore the range of fall velocity used for the present study is reasonable. In fact, the fall velocity of 0.01 cm/sec would be the most representative value; thus, when discussing the simulated results, attention is directed toward the fall velocity of 0.01 cm/sec.

The computer model results are presented in tabular form in Tables 3-4 to 3-7 using the dimensions given for the dump vessel. Tables 3-4 and

Table 3-4. Results of Summer Waste Dilution, Q = 500 gpm.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
				Vfall = 1 cm/s			Vfall = 0.1 cm/s			Vfall = 0.01 cm/s		
T(hr)	X(n mi)	U(kt)	Co	Y1(m)	Cmax/Co	Ratio	Y2(m)	Cmax/Co	Ratio	Y3(m)	Cmax/Co	Ratio
5.0	1.0	.2	.000222	180.0	.05423	.33	18.0	.04999	.36	1.8	.04999	.36
7.5	1.5	.2	.000222	270.0	.03242	.56	27.0	.03038	.59	2.7	.03038	.59
10.0	2.0	.2	.000222	360.0	.02172	.83	36.0	.02052	.88	3.6	.02052	.88
12.5	2.5	.2	.000222	450.0	.01562	1.15	45.0	.01482	1.22	4.5	.01482	1.22
15.0	3.0	.2	.000222	540.0	.01179	1.53	54.0	.01133	1.59	5.4	.01122	1.61
17.5	3.5	.2	.000222	630.0	.00922	1.95	63.0	.00947	1.90	6.3	.00880	2.05
20.0	4.0	.2	.000222	720.0	.00741	2.43	72.0	.00805	2.24	7.2	.00709	2.54
2.5	1.0	.4	.000222	90.0	.05794	.31	9.0	.05035	.36	.9	.05035	.36
3.7	1.5	.4	.000222	135.0	.03798	.47	13.5	.03430	.53	1.3	.03430	.53
5.0	2.0	.4	.000222	180.0	.02726	.66	18.0	.02507	.72	1.8	.02507	.72
6.3	2.5	.4	.000222	225.0	.02067	.87	22.5	.01920	.94	2.2	.01920	.94
7.5	3.0	.4	.000222	270.0	.01627	1.11	27.0	.01522	1.18	2.7	.01522	1.18
8.8	3.5	.4	.000222	315.0	.01317	1.37	31.5	.01238	1.46	3.1	.01238	1.46
10.0	4.0	.4	.000222	360.0	.01089	1.65	36.0	.01028	1.75	3.6	.01028	1.75
1.2	1.0	.8	.000222	45.0	.04207	.43	4.5	.04207	.43	.5	.04207	.43
1.9	1.5	.8	.000222	67.5	.03532	.51	6.8	.03183	.57	.7	.03183	.57
2.5	2.0	.8	.000222	90.0	.02859	.63	9.0	.02521	.71	.9	.02521	.71
3.1	2.5	.8	.000222	112.5	.02287	.79	11.3	.02058	.88	1.1	.02058	.88
3.7	3.0	.8	.000222	135.0	.01883	.96	13.5	.01717	1.05	1.3	.01717	1.05
4.4	3.5	.8	.000222	157.5	.01585	1.14	15.8	.01457	1.24	1.6	.01457	1.24
5.0	4.0	.8	.000222	180.0	.01355	1.33	18.0	.01254	1.44	1.8	.01254	1.44

Table 3-5. Results of Summer Waste Dilution, Q = 1400 gpm.

				Vfall = 1 cm/s			Vfall = 0.1 cm/s			Vfall = 0.01 cm/s		
T(hr)	X(n mi)	U(kt)	Co	Y1(m)	Cmax/Co	Ratio	Y2(m)	Cmax/Co	Ratio	Y3(m)	Cmax/Co	Ratio
5.0	1.0	.2	.000621	180.0	.05423	.12	18.0	.05060	.13	1.8	.05000	.13
7.5	1.5	.2	.000621	270.0	.03242	.20	27.0	.03039	.21	2.7	.03039	.21
10.0	2.0	.2	.000621	360.0	.02172	.30	36.0	.02052	.31	3.6	.02052	.31
12.5	2.5	.2	.000621	450.0	.01562	.41	45.0	.01483	.43	4.5	.01483	.43
15.0	3.0	.2	.000621	540.0	.01179	.55	54.0	.01133	.57	5.4	.01123	.57
17.5	3.5	.2	.000621	630.0	.00922	.70	63.0	.00947	.68	6.3	.00888	.73
20.0	4.0	.2	.000621	720.0	.00741	.87	72.0	.00805	.88	7.2	.00709	.91
2.5	1.0	.4	.000621	90.0	.05795	.11	9.0	.05036	.13	.9	.05036	.13
3.7	1.5	.4	.000621	135.0	.03799	.17	13.5	.03430	.19	1.3	.03430	.19
5.0	2.0	.4	.000621	180.0	.02727	.24	18.0	.02507	.26	1.8	.02507	.26
6.3	2.5	.4	.000621	225.0	.02067	.31	22.5	.01921	.34	2.2	.01921	.34
7.5	3.0	.4	.000621	270.0	.01627	.40	27.0	.01522	.42	2.7	.01522	.42
8.8	3.5	.4	.000621	315.0	.01317	.49	31.5	.01238	.52	3.1	.01238	.52
10.0	4.0	.4	.000621	360.0	.01089	.59	36.0	.01028	.63	3.6	.01028	.63
1.2	1.0	.8	.000621	45.0	.04208	.15	4.5	.04208	.15	.5	.04209	.15
1.9	1.5	.8	.000621	67.5	.03533	.18	6.8	.03184	.20	.7	.03184	.20
2.5	2.0	.8	.000621	90.0	.02859	.23	9.0	.02522	.26	.9	.02522	.26
3.1	2.5	.8	.000621	112.5	.02287	.28	11.3	.02058	.31	1.1	.02058	.31
3.7	3.0	.8	.000621	135.0	.01884	.34	13.5	.01717	.37	1.3	.01717	.37
4.4	3.5	.8	.000621	157.5	.01585	.41	15.8	.01457	.44	1.6	.01457	.44
5.0	4.0	.8	.000621	180.0	.01355	.47	18.0	.01254	.51	1.8	.01254	.51

Table 3-6. Results of Winter Waste Dilution, Q = 500 gpm.

				Vfall = 1 cm/s			Vfall = 0.1 cm/s			Vfall = 0.01 cm/s		
T(hr)	X(n mi)	U(kt)	Co	Y1(m)	Cmax/Co	Ratio	Y2(m)	Cmax/Co	Ratio	Y3(m)	Cmax/Co	Ratio
5.0	1.0	.2	.000222	180.0	.03364	.54	18.0	.03364	.54	1.8	.03364	.54
7.5	1.5	.2	.000222	270.0	.02043	.88	27.0	.02043	.88	2.7	.02043	.88
10.0	2.0	.2	.000222	360.0	.01379	1.31	36.0	.01379	1.31	3.6	.01379	1.31
12.5	2.5	.2	.000222	450.0	.00996	1.81	45.0	.00996	1.81	4.5	.00996	1.81
15.0	3.0	.2	.000222	540.0	.00754	2.39	54.0	.00754	2.39	5.4	.00754	2.39
17.5	3.5	.2	.000222	630.0	.00591	3.05	63.0	.00591	3.05	6.3	.00591	3.05
20.0	4.0	.2	.000222	720.0	.00476	3.78	72.0	.00476	3.78	7.2	.00476	3.78
2.5	1.0	.4	.000222	90.0	.03385	.53	9.0	.03385	.53	.9	.03385	.53
3.7	1.5	.4	.000222	135.0	.02305	.78	13.5	.02305	.78	1.3	.02305	.78
5.0	2.0	.4	.000222	180.0	.01684	1.07	18.0	.01684	1.07	1.8	.01684	1.07
6.3	2.5	.4	.000222	225.0	.01290	1.40	22.5	.01290	1.40	2.2	.01290	1.40
7.5	3.0	.4	.000222	270.0	.01022	1.76	27.0	.01022	1.76	2.7	.01022	1.76
8.8	3.5	.4	.000222	315.0	.00831	2.17	31.5	.00831	2.17	3.1	.00831	2.17
10.0	4.0	.4	.000222	360.0	.00690	2.61	36.0	.00690	2.61	3.6	.00690	2.61
1.2	1.0	.8	.000222	45.0	.02827	.64	4.5	.02827	.64	.5	.02827	.64
1.9	1.5	.8	.000222	67.5	.02138	.84	6.8	.02138	.84	.7	.02138	.84
2.5	2.0	.8	.000222	90.0	.01693	1.06	9.0	.01693	1.06	.9	.01693	1.06
3.1	2.5	.8	.000222	112.5	.01382	1.30	11.3	.01382	1.30	1.1	.01382	1.30
3.7	3.0	.8	.000222	135.0	.01153	1.56	13.5	.01153	1.56	1.3	.01153	1.56
4.4	3.5	.8	.000222	157.5	.00979	1.84	15.8	.00979	1.84	1.6	.00979	1.84
5.0	4.0	.8	.000222	180.0	.00842	2.14	18.0	.00842	2.14	1.8	.00842	2.14

Table 3-7. Results of Winter Waste Dilution, Q = 1400 gpm.

				Vfall = 1 cm/s			Vfall = 0.1 cm/s			Vfall = 0.01 cm/s		
T(hr)	X(n mi)	U(kt)	Co	Y1(m)	Cmax/Co	Ratio	Y2(m)	Cmax/Co	Ratio	Y3(m)	Cmax/Co	Ratio
5.0	1.0	.2	.000621	180.0	.03364	.19	18.0	.03364	.19	1.8	.03364	.19
7.5	1.5	.2	.000621	270.0	.02043	.32	27.0	.02043	.32	2.7	.02043	.32
10.0	2.0	.2	.000621	360.0	.01380	.47	36.0	.01380	.47	3.6	.01380	.47
12.5	2.5	.2	.000621	450.0	.00996	.65	45.0	.00996	.65	4.5	.00996	.65
15.0	3.0	.2	.000621	540.0	.00754	.85	54.0	.00754	.85	5.4	.00754	.85
17.5	3.5	.2	.000621	630.0	.00591	1.09	63.0	.00591	1.09	6.3	.00591	1.09
20.0	4.0	.2	.000621	720.0	.00476	1.35	72.0	.00476	1.35	7.2	.00476	1.35
2.5	1.0	.4	.000621	90.0	.03385	.19	9.0	.03385	.19	.9	.03385	.19
3.7	1.5	.4	.000621	135.0	.02385	.28	13.5	.02385	.28	1.3	.02385	.28
5.0	2.0	.4	.000621	180.0	.01684	.38	18.0	.01684	.38	1.8	.01684	.38
6.3	2.5	.4	.000621	225.0	.01290	.50	22.5	.01290	.50	2.2	.01290	.50
7.5	3.0	.4	.000621	270.0	.01022	.63	27.0	.01022	.63	2.7	.01022	.63
8.8	3.5	.4	.000621	315.0	.00832	.77	31.5	.00832	.77	3.1	.00832	.77
10.0	4.0	.4	.000621	360.0	.00690	.93	36.0	.00690	.93	3.6	.00690	.93
1.2	1.0	.8	.000621	45.0	.02827	.23	4.5	.02827	.23	.5	.02827	.23
1.9	1.5	.8	.000621	67.5	.02130	.30	6.8	.02130	.30	.7	.02130	.30
2.5	2.0	.8	.000621	90.0	.01694	.38	9.0	.01694	.38	.9	.01694	.38
3.1	2.5	.8	.000621	112.5	.01382	.47	11.3	.01382	.47	1.1	.01382	.47
3.7	3.0	.8	.000621	135.0	.01153	.56	13.5	.01153	.56	1.3	.01153	.56
4.4	3.5	.8	.000621	157.5	.00979	.66	15.8	.00979	.66	1.6	.00979	.66
5.0	4.0	.8	.000621	180.0	.00842	.76	18.0	.00842	.76	1.8	.00842	.76

3-5 show the results for the summer months, with discharge rates Q = 500 gpm and Q = 1400 gpm, respectively. To interpret the results, it is fruitful to note the various items shown in each of the tables. The first column in Table 3-4 is the time after the initial release of the waste material. The second column converts the time into distance from the discharge point. In the third column, three different current speeds, namely 0.2 knots, 0.4 knots, and 0.8 knots are included. Based on Equation (3.1) the initial mean concentration, Co, is computed. For a discharge rate of 500 gpm Co is computed to be 0.000222. The vertical location of the centerline of the plume at different times for a fall velocity of 1 cm/sec is shown in the fifth column. The concentration at the centerline of the plume Cmax normalized with respect to Co is shown in column 6. The dilution, which can be obtained as the reciprocal of (Co) (Cmax/Co), can easily be obtained by the inverse of the value in column 4 multiplied by that in column 6. According to Soule and Oguri (1983) and Section III.A.2.C.1 of this report, the limiting permissible concentration (LPC) of the waste being discharged is 0.0004 % concentration of the fish waste. This value of concentration corresponds to a dilution of 250,000. Therefore, for convenience the dilution ratio has been normalized with respect to 250,000 and such ratio is presented in column 7. For the fall velocity of 0.1 cm/sec the corresponding results are presented in columns 8 to 10. Similarly the results for 0.01 cm/sec fall velocity are shown in columns 11 to 13. Thus, when one reads the value at columns 7, 10, and 13, a value of 1.00 implies the dilution of 250,000. A value greater than 1.0 implies a dilution greater than 250,000.

The major difference between the summer months and winter months is for the value of vertical diffusion. For the winter months, larger vertical diffusions were used causing more mixing and thus a larger dilution. It can be seen that a greater mixing, therefore larger dilution, is achieved in the winter months (Tables 3-6 and 3-7) in comparison with the corresponding results for that in the summer months (Tables 3-4 and 3-5).

The results presented in Tables 3-4 to 3-7 can be plotted to provide a better picture of the extent of the waste plume following a prescribed current direction. Based on the available data the two observed directions at the discharge site are SW and NW. The waste plume is therefore advected along these directions while experiencing a lateral mixing along the way.

3.3 Extent of the Plume at the Present Site

To show the extent of the plume. at the present site, curves containing a series of equi-dilution lines are presented in Figures 3-3 and 3-4 (based on the results presented in Tables 3-4 and 3-6 respectively). The dilution ratios shown are the dilutions normalized with respect to 250,000 (LPC) for both the summer and winter months and for current speeds of 0.2 knots, 0.4 knots. and 0.8 knots. The discharge rate for these figures is 500 gpm and the fall velocity is set at 0.01 cm/sec.

Figure 3-5 shows the equi-dilution lines in the summer months plotted on the map for a waste discharge of 500 gpm in a current of 0.2 knots towards the SW direction. Two different equi-dilution lines are drawn: the line for 0.5 represents a dilution of 125,000, while the line for 1.0 represents a dilution of 250,000. Such a favorable current direction would continue to carry the plume away in the SW direction. Thus, the plume would not reach the shore region while undergoing a significant mixing and diffusion.

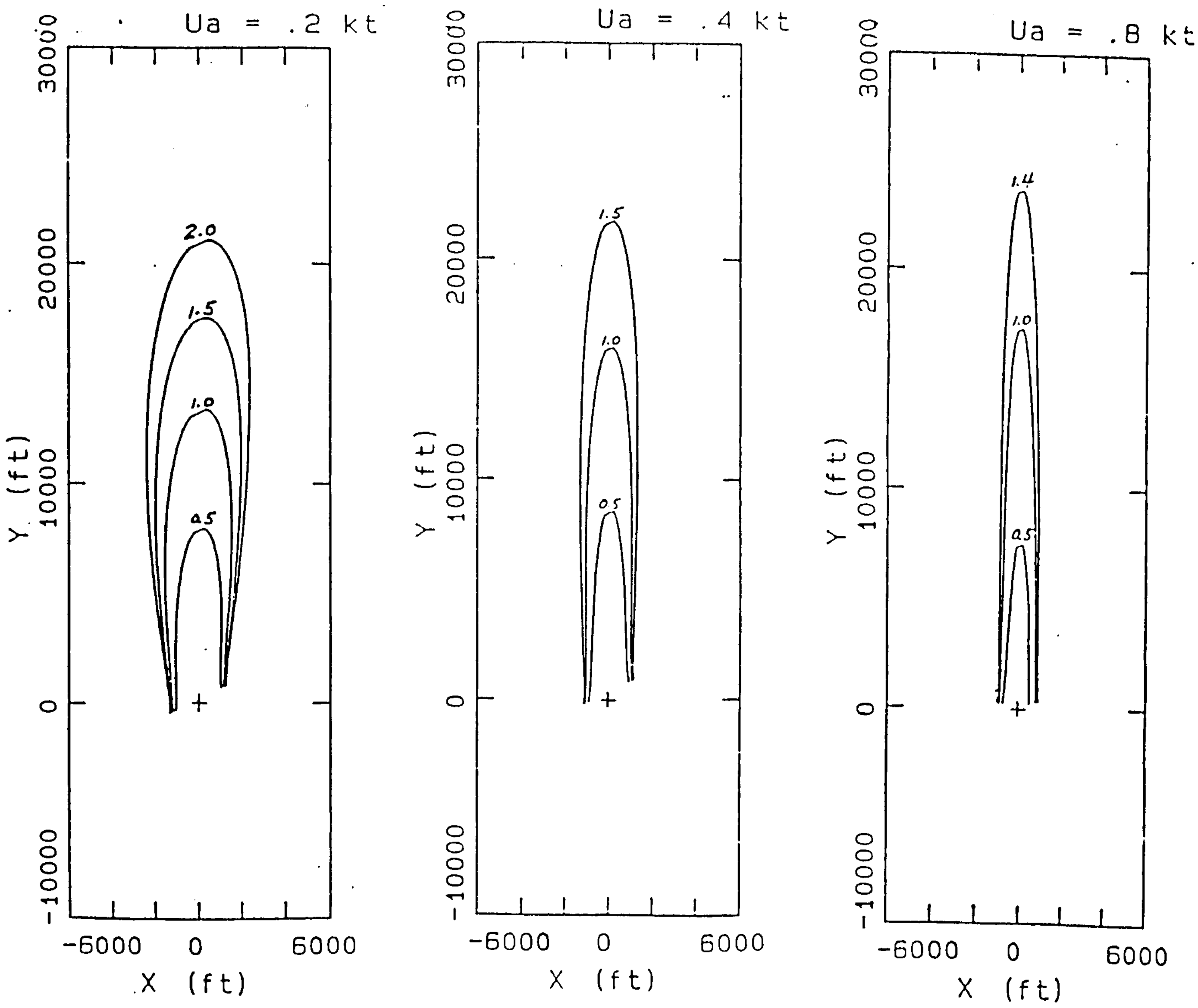

Figure 3-3. Equi-dilution lines of discharge waste plume, summer months. (Q = 500 gpm, Vfall = 0.01 cm/s, Ua = 0.2, 0.4, 0.8 kt).

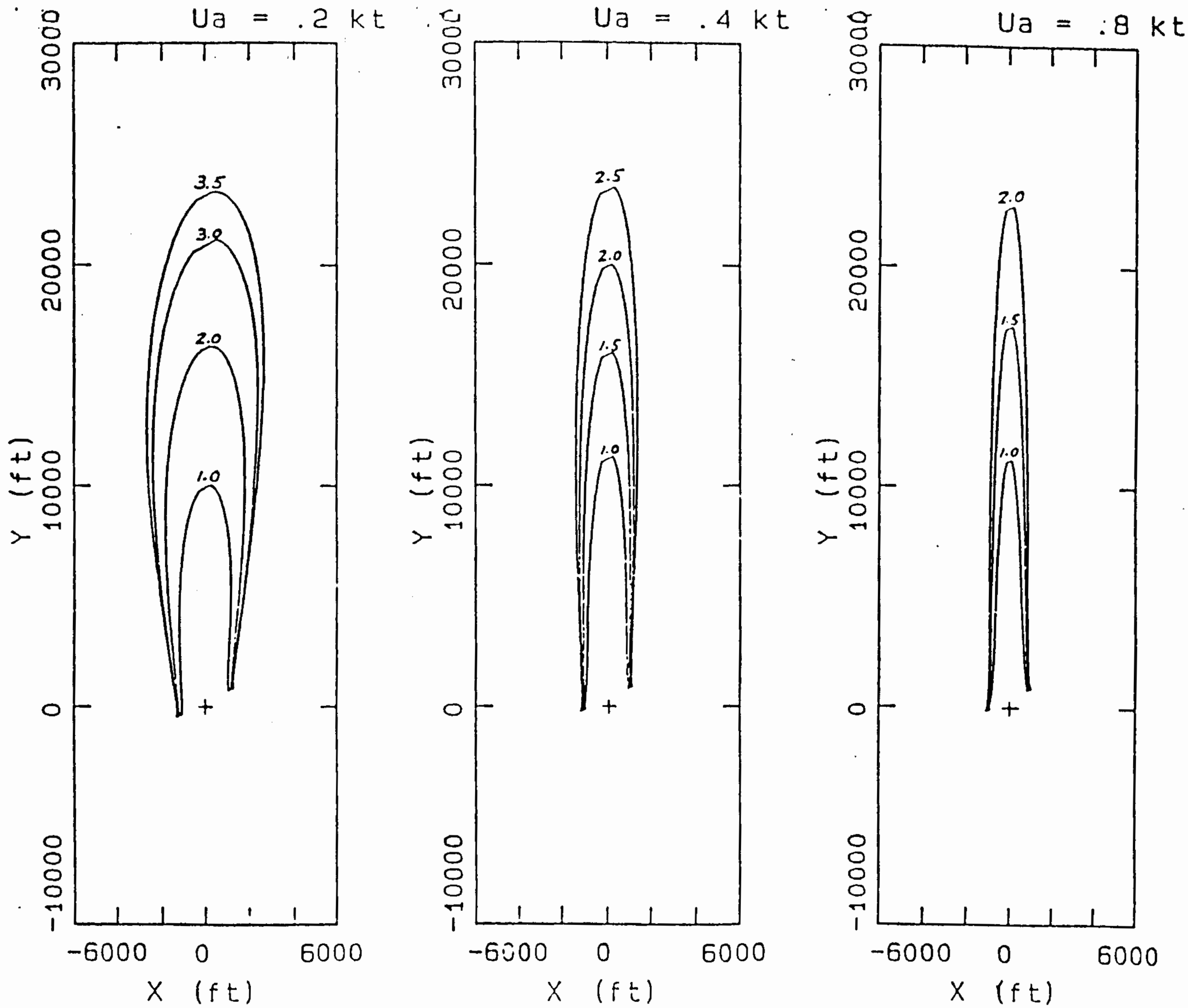

Figure 3-4. Equi-dilution lines of discharge waste plume, winter months. (Q = 500 gpm, Vfall = 0.01 cm/s, Ua = 0.2, 0.4, 0.8 kt).

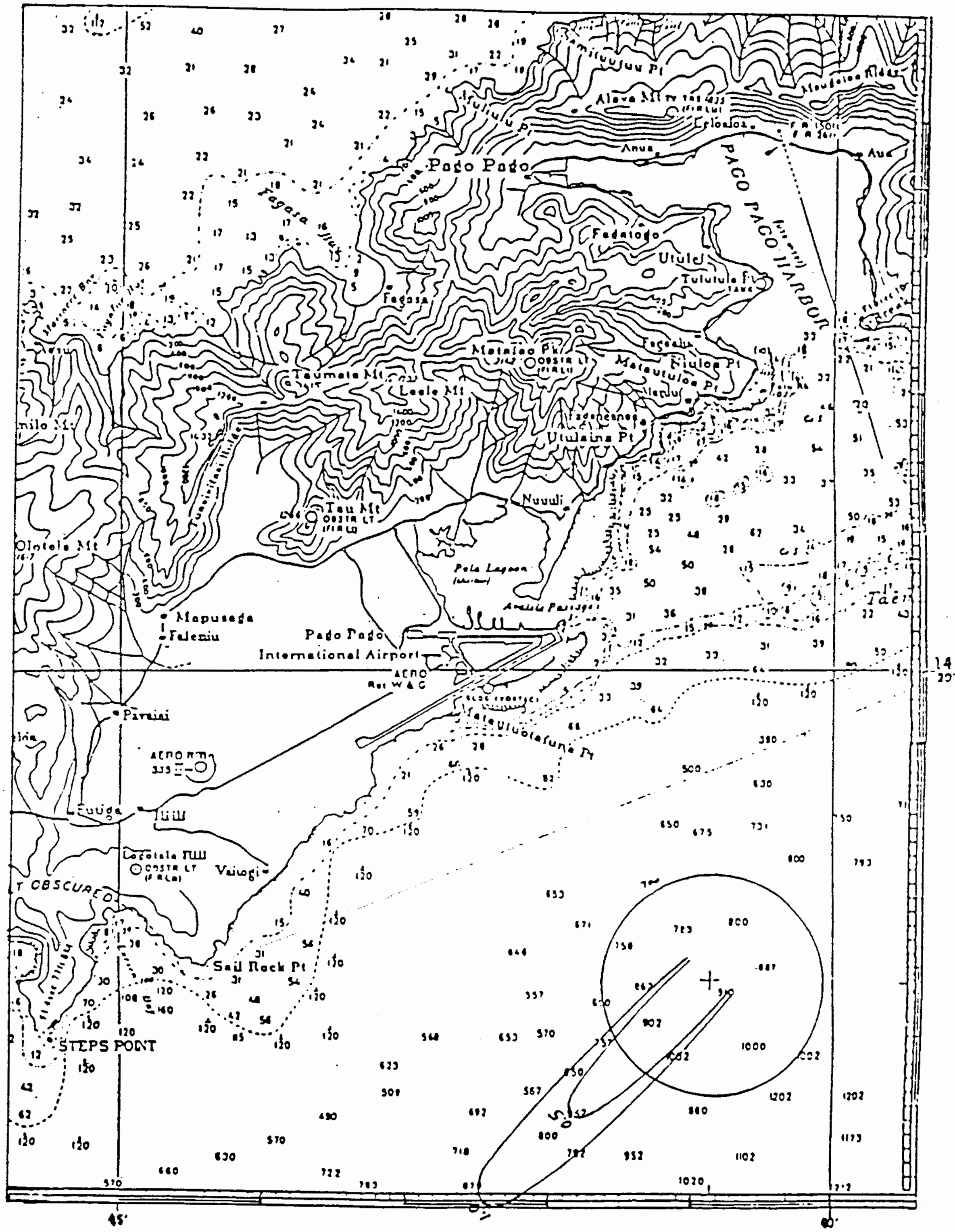

Figure 3-5. Equi-dilution lines of discharge waste plume, summer months SW current (Q = 500 gpm, Vfall = 0.01 cm/s Ua = 0.2 kt).

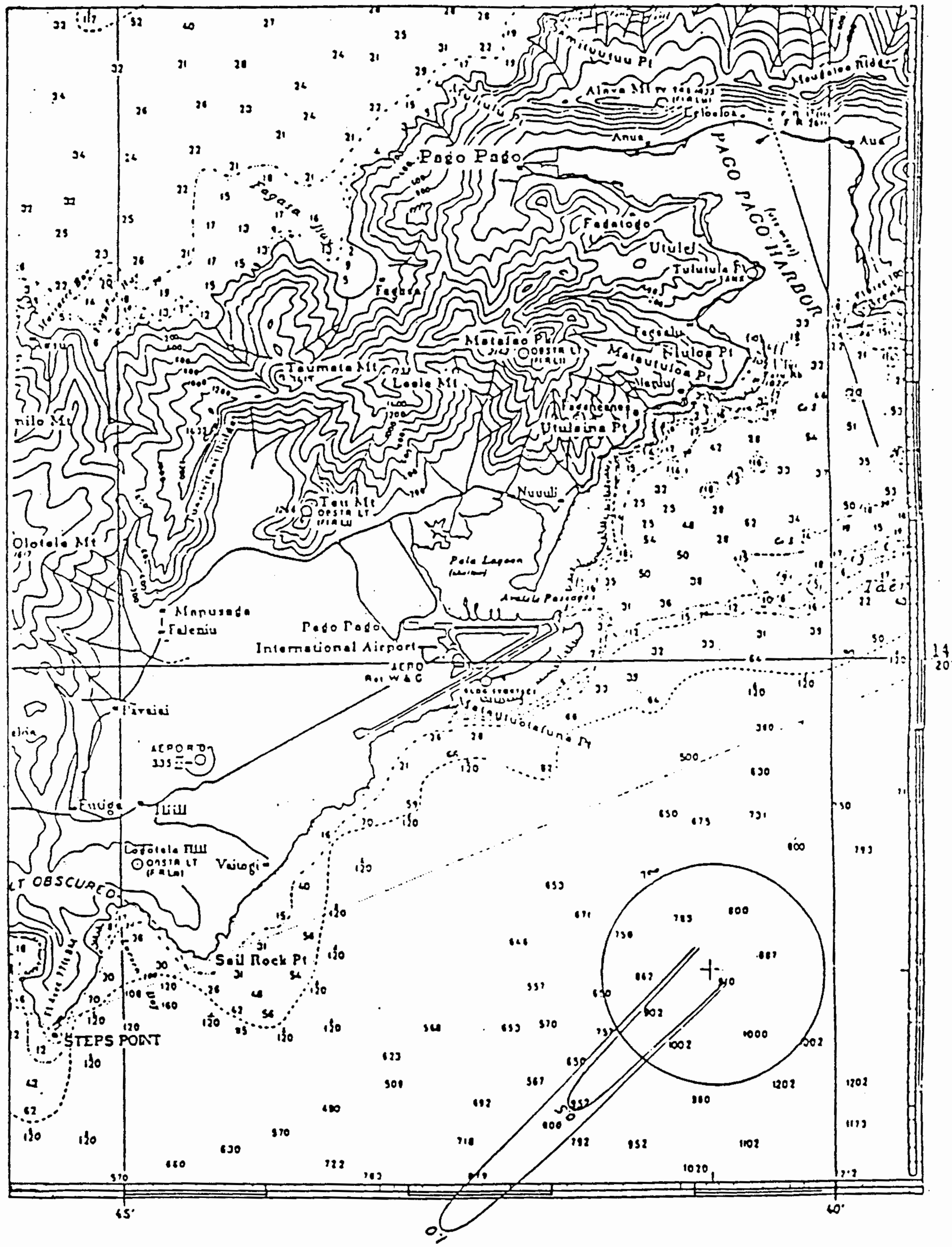

Figure 3-6. Equi-dilution lines of discharge waste plume, summer months SW current (Q = 500 gpm, Vfall = 0.01 cm/s Ua = 0.4 kt).

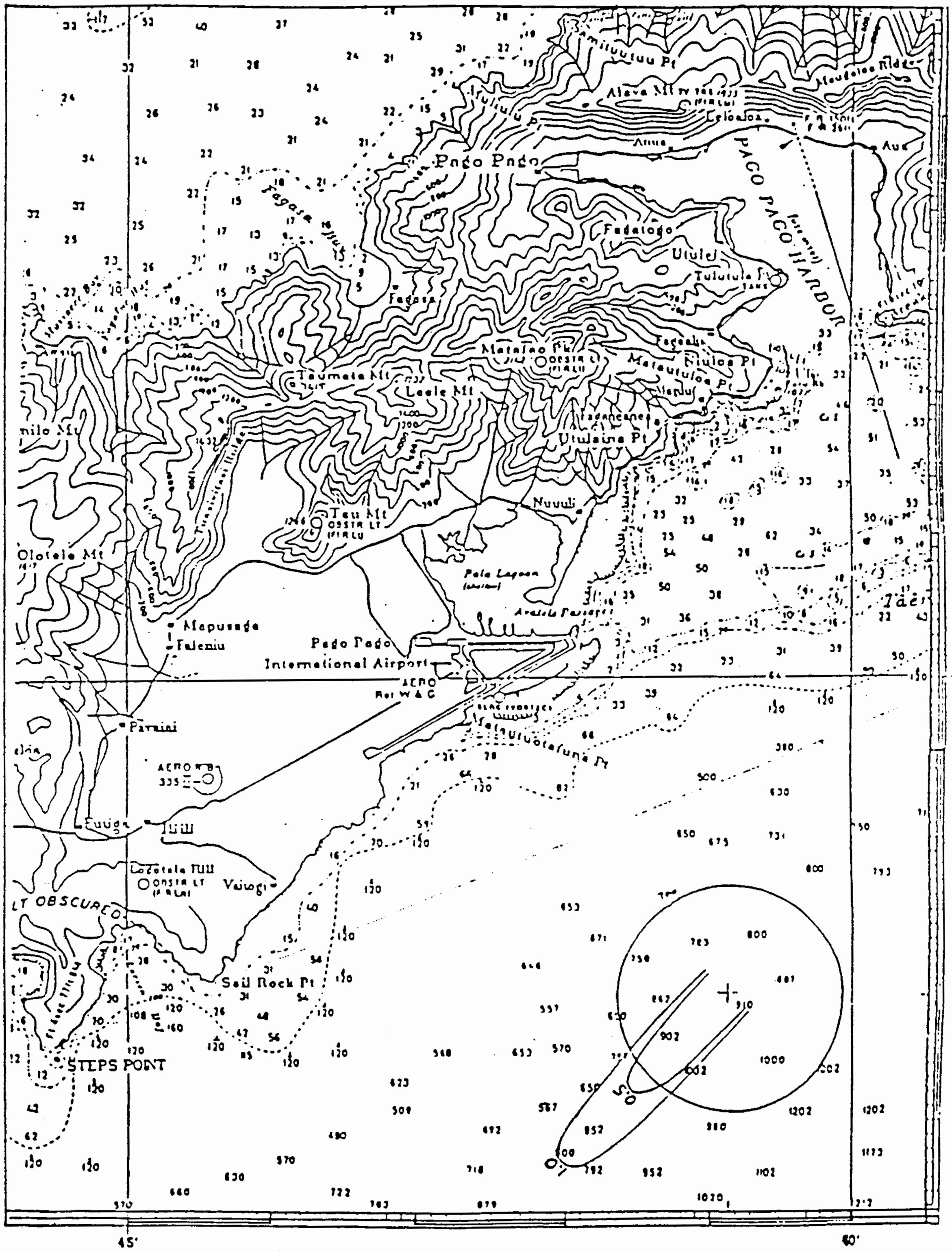

Figure 3-7. Equi-dilution lines of discharge waste plume, winter months SW current (Q = 500 gpm, Vfall = 0.01 cm/s Ua = 0.2 kt).

Figure 3-6 shows the extent of the waste plume with a SW current of 0.4 kt. Comparing the results in Figure 3-6 with those in Figure 3-5, one observes that the effect of a stronger current is to advect the plume swiftly downstream in the current direction. Therefore, the extent of lateral diffusion is much narrower.

Figures 3-7 and 3-8 show the corresponding pictures for the winter months. By comparing these results with those presented in Figures 3-5 and 3-6, one can observe that a greater dilution is achieved in the winter months due to increased vertical diffusion.

The drogue studies conducted by Soule and Oguri (1984) indicate a current toward the southwest (SW) direction and that the data on the surface current presented in Figure III.8 also show predominant southwest surface current. However, some 1987 current meter data detect current in the northwest (NW) direction. Some current data indicated that a current in the southwest direction with a magnitude of 0.25 knots outside of the 120-fathom depth contour (CH2M Hill, 1976). A sketch confirming the direction of drogue movement (along the SW direction) after CH2M Hill is shown in Figure 3-9. Since the coastal current normally follows the depth contour, it is reasonable to expect a worst case illustration having a NW current (0.2 knots) at the dumpsite would at first carry the plume initially in the NW direction; however, as the plume propagates toward the shore the current will gradually bend the plume in a pattern such as shown in Figure 3-10. In fact, the simulated plume trajectory for this worst case scenario is illustrated in Figure 3-11. In Figure 3-11 the equi-dilution lines are drawn for the summer months with a waste discharge of 500 gpm in a current of 0.2 knots toward the NW direction at the dumpsite. It is seen that the dilution ratio of 1.0 (corresponds to 250,000

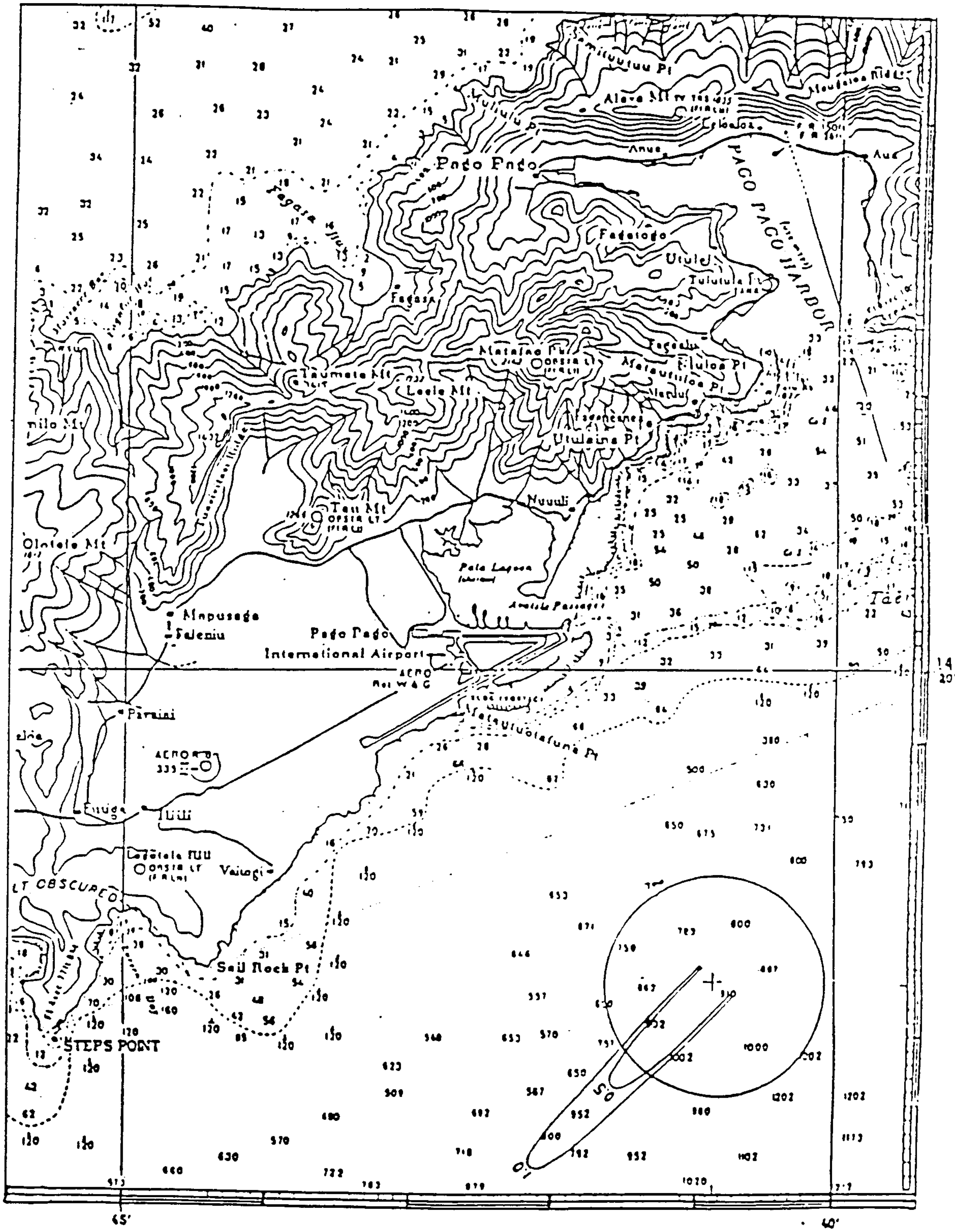

Figure 3-8. Equi-dilution lines of discharge waste plume, winter months SW current (Q = 500 gpm, Vfall = 0.01 cm/s Ua = 0.4 kt).

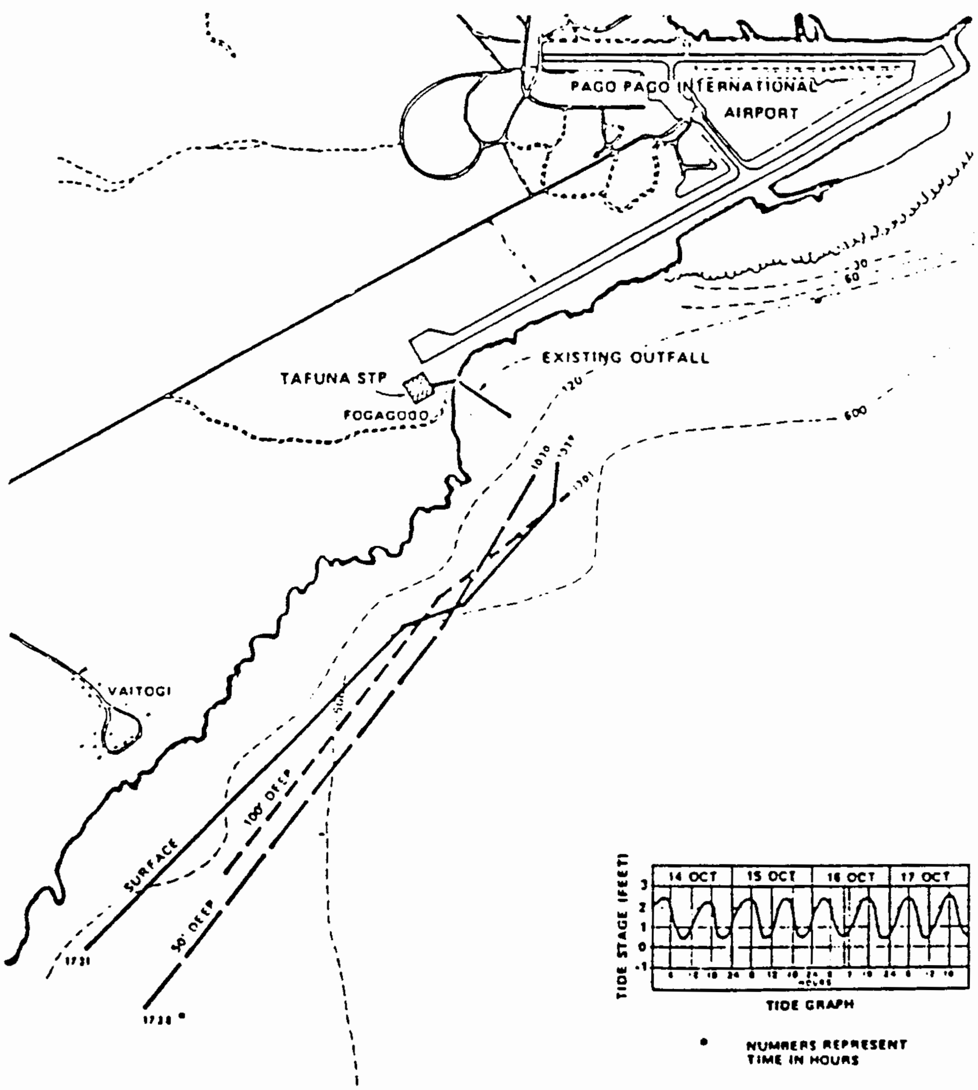

Figure 3-9. Drogue movement along shore (after CH2M Hill, 1976).

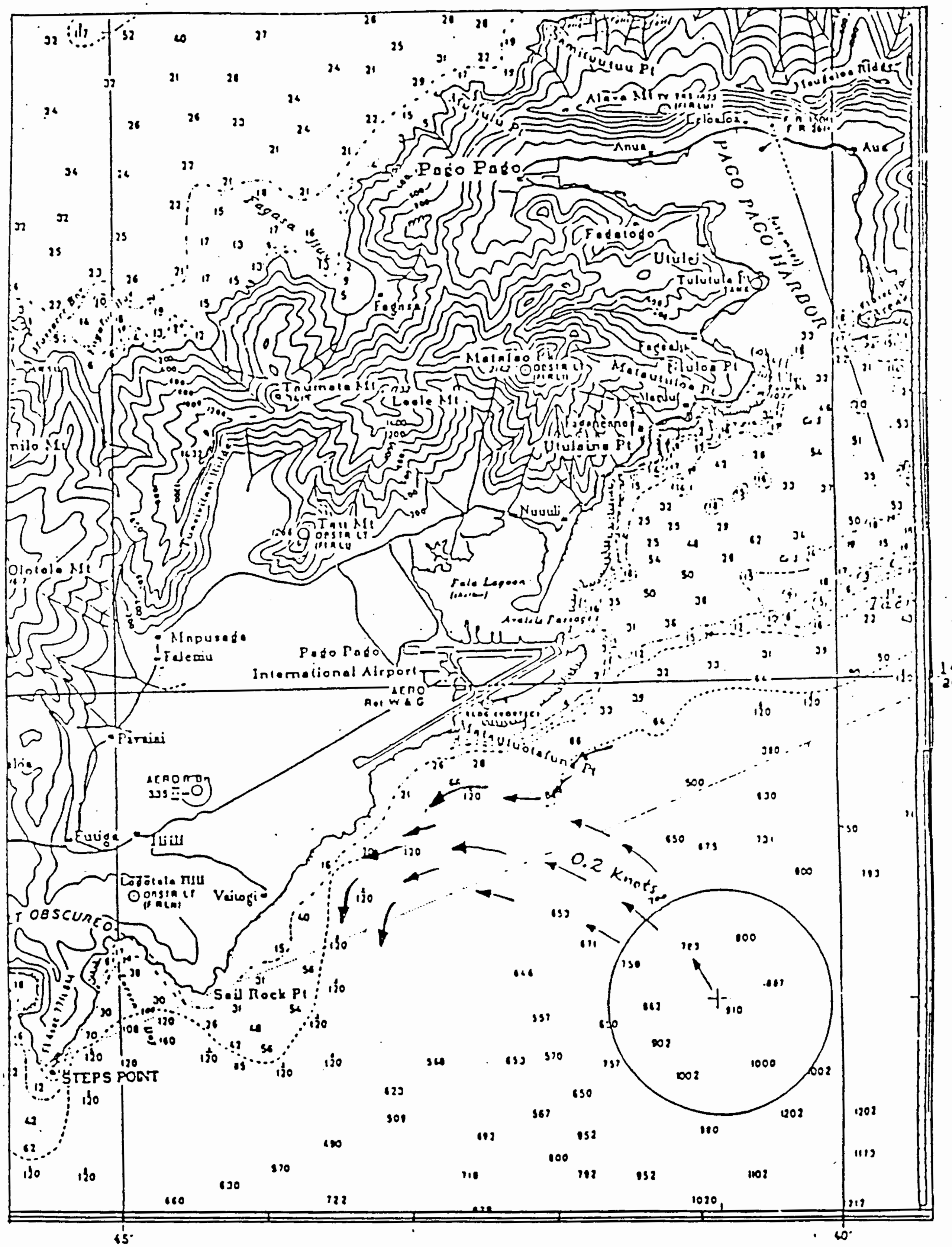

Figure 3.10. The expected near shore current pattern assuming the worst case scenario of NW current at the dumpsite.

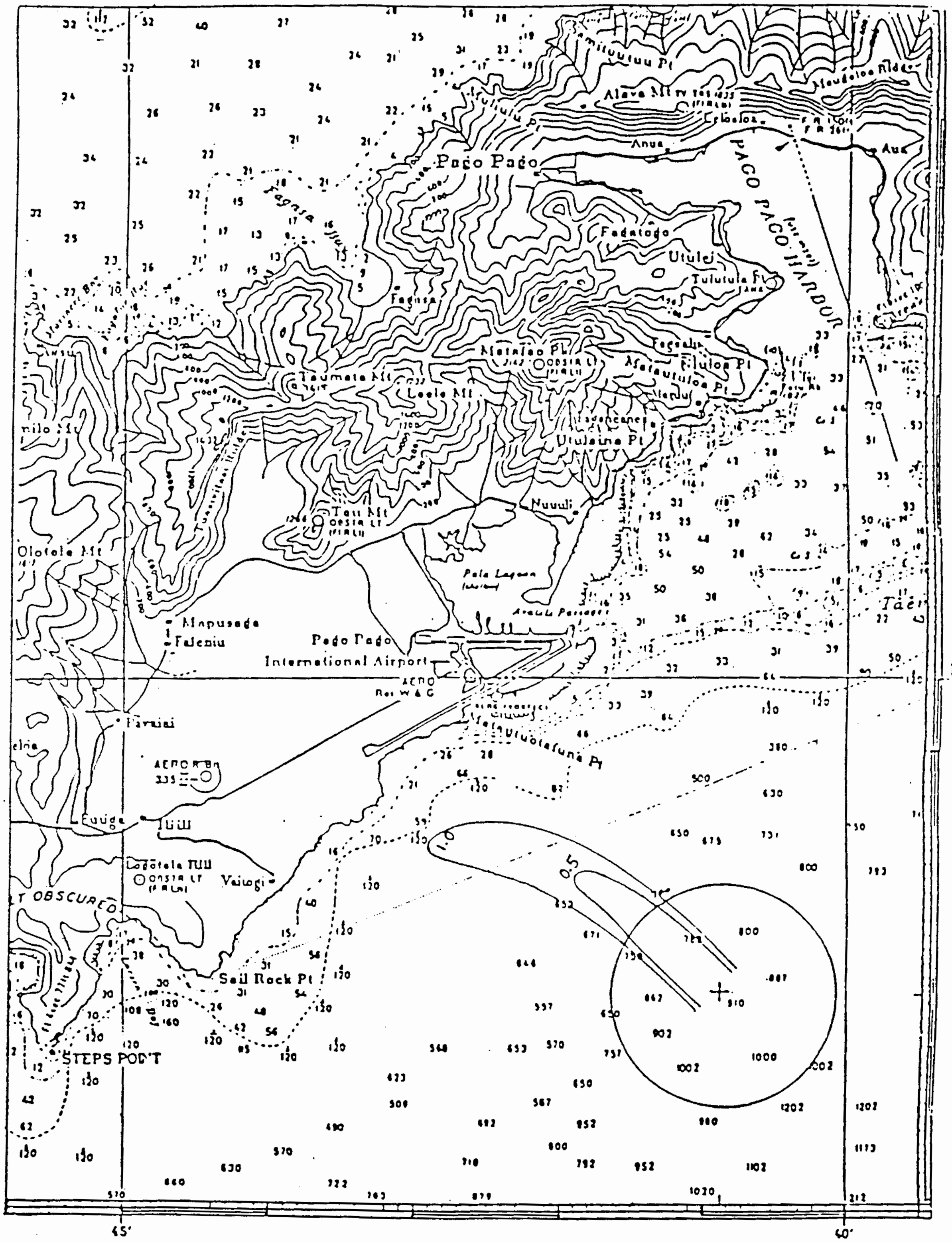

Figure 3-11. The worst-case illustration of the direction of the plume without the SW longshore current. the 250,000 dilution is reached before the plume reaches the 120 fm depth contour. Equi-dilution lones of discharge waste plume, summer months NW current (Q = 500 gpm, Vfall = 0.01 cm/s, Ua = 0.2 kt).

dilution) does not even reach a region at the 120-fathom contour, where significant change in water depth occurs. The longshore current in the SW direction would carry the plume in that direction, preventing the plume from reaching the shore region.

The longshore current to the SW is described in Section III.B.2.b. Therefore, the plume is expected to gradually bend toward the SW direction following the depth contour line (a direction along island shoreline) carrying the plume with it. In order to make a further, detailed prediction of the direction and the extent of the plume in this shallower water region, more definitive information on the seaward extent of the longshore current and its magnitude is needed. It should be emphasized that the results in Figure 3-9 are for the summer months. Results for the winter months would indicate more mixing, therefore greater dilution within the region shown.

3.4 Extent of Plume at Deeper Water Preferred Site.

With the selection of the deeper water site as the preferred site, the curves containing the equi-dilution lines were plotted for the same conditions shown in Figures 3-5 through 3-8 and 3-11 and discussed in Sectin 33. The results are shown in Figures 3-12 through 3-16.

Although the plumes are plotted from the center of the site, it has been recommended to EPA that the dump protocol be changed. The dump vessel would make observations of the surface current direction before dumping begins and dump at the upstream periphery, circling within the dumpsite during discharge. This would result in the plumes being dissipated to the LPC concentration of 1:250,000 within the dumpsite under most conditions.

The plume would not move inshore sufficiently to reach the longshore

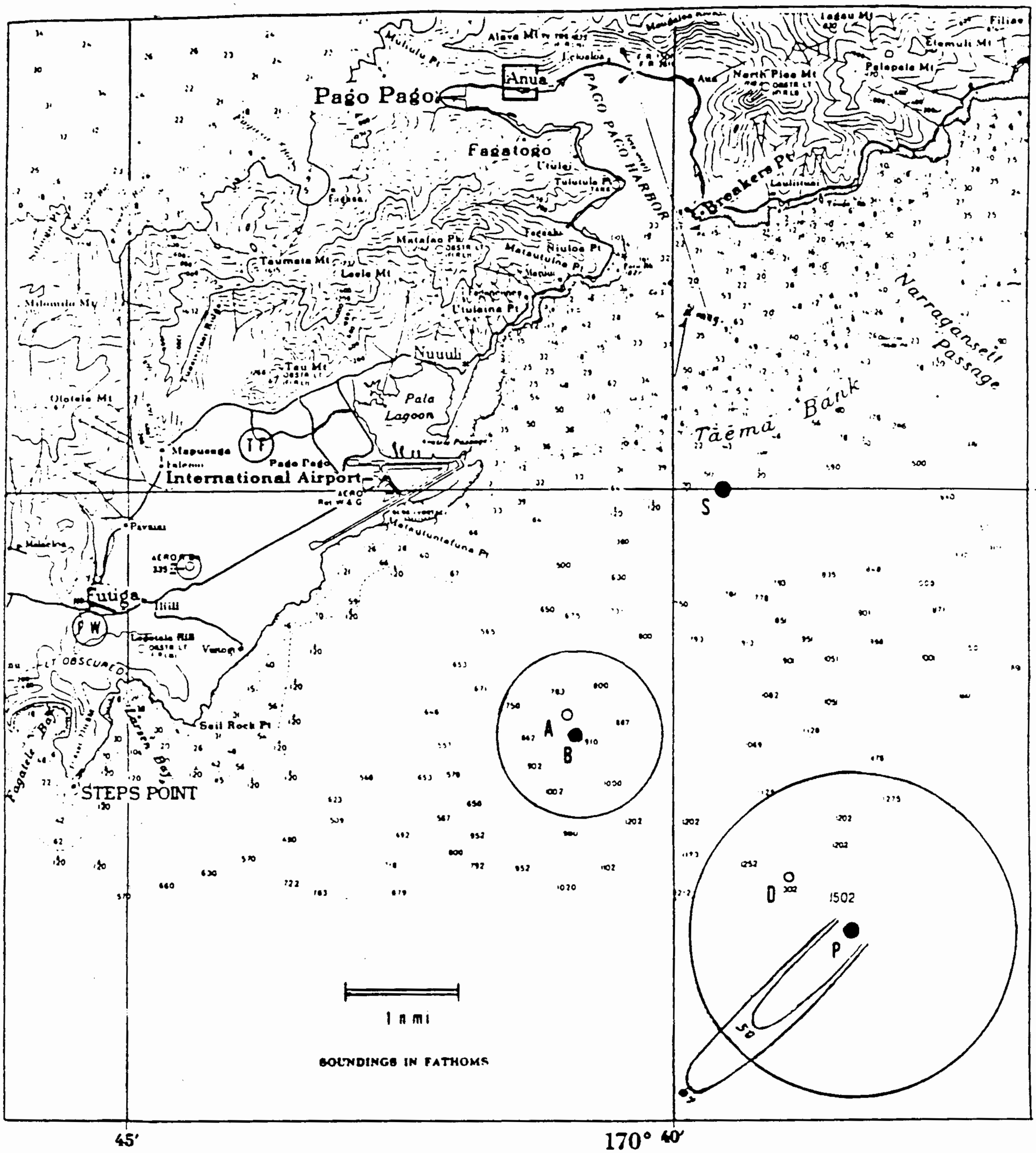

Figure 3-12. Equi-dilution lines of discharge waste plume, summer months SW current (Q= 500 gpm, Vfall = 0.01 cm/s Ua = 0.2 kt). If dumping were to take place at the NE periphery under these conditions, the plume would be fully dissipated, reaching background levels, within the dumpsite circle.

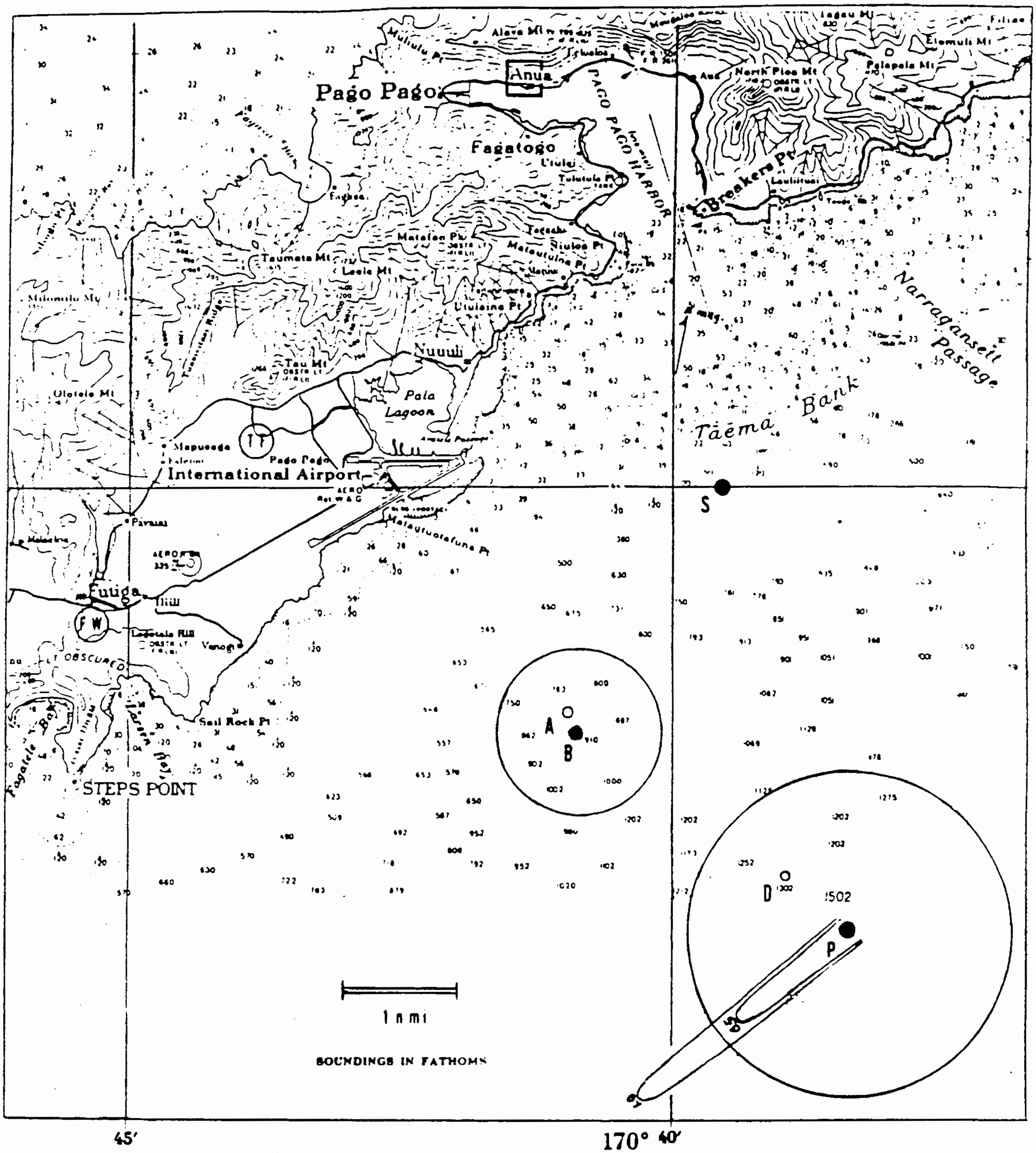

Figure 3-13. Equi-dilution lines of discharge waste plume, summer months SW current (Q = 500 gpm, Vfall = 0.01 cm/s Ua = 0.4 kt). If dumping were to take place at the NE periphery under these conditions, the plume would be mostly dissipated within the dump circle.

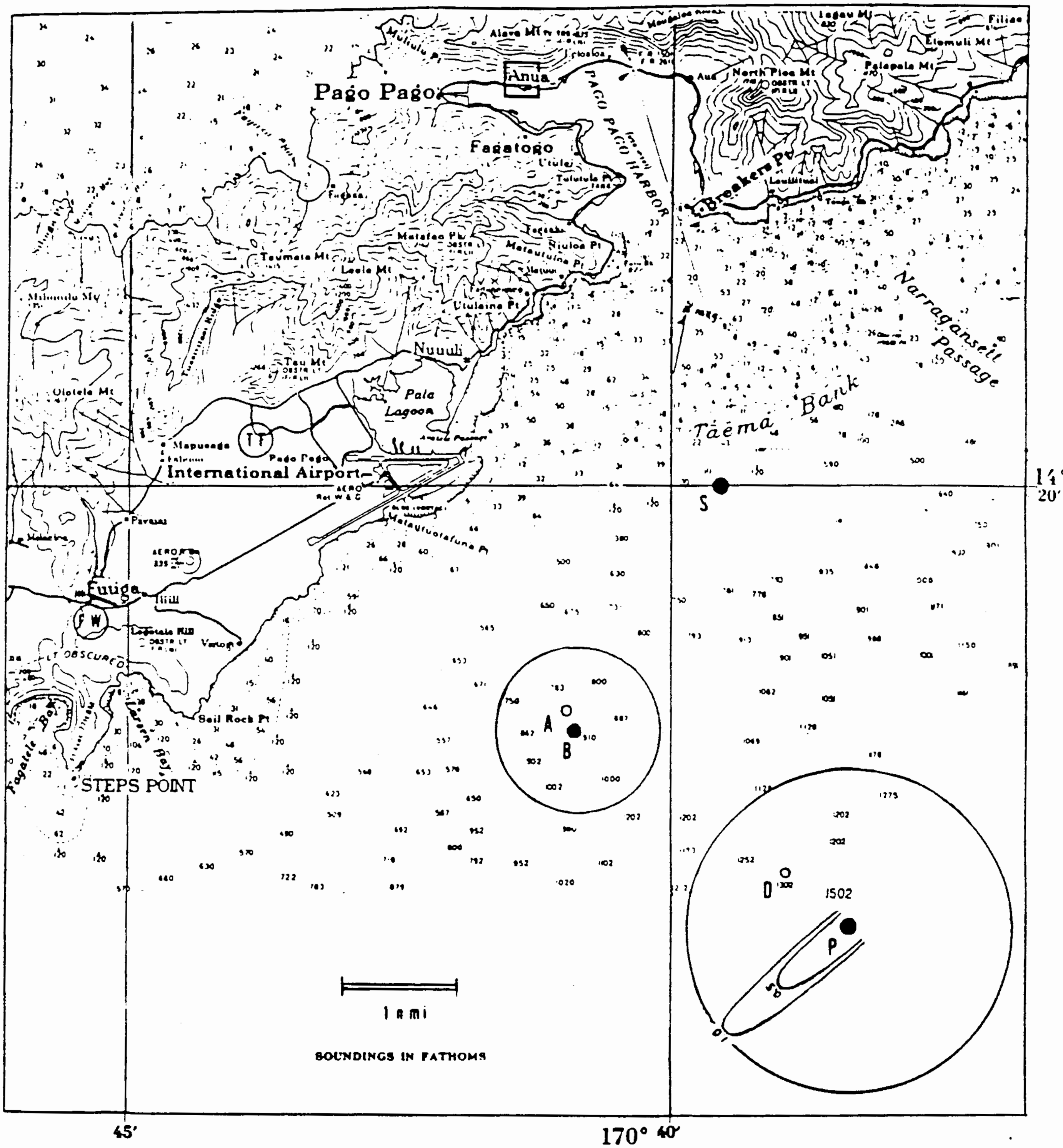

Figure 3-14. Equi-dilution lines of discharge waste plume, winter months SW current (Q = 500 gpm, Vfall = 0.01 cm/s Ua = 0.2 kt). If dumping were to take place at the NE periphery under these conditions, the plume would be dissipated within the dumpsite circle.

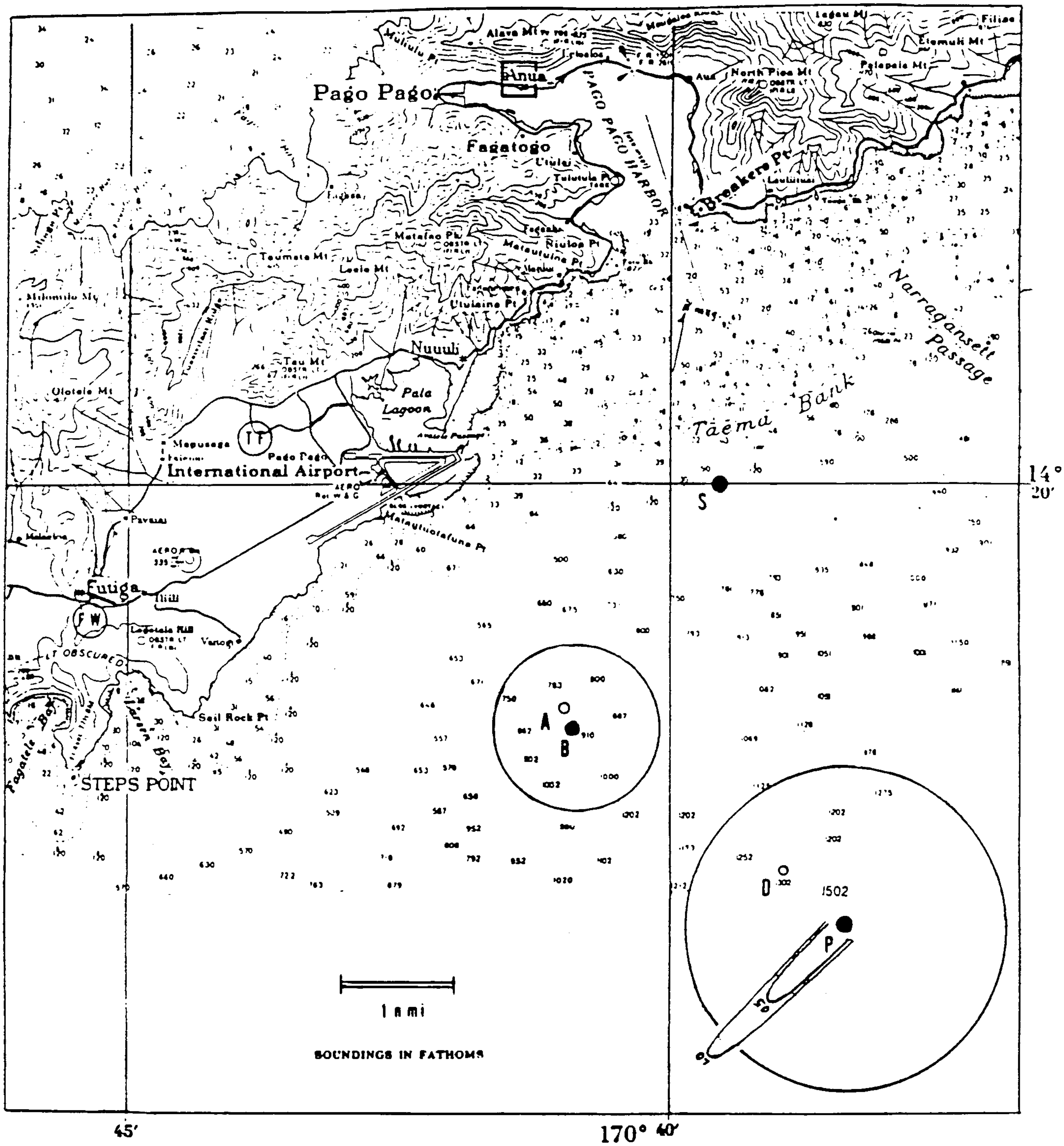

Figure 3-15. Equi-dilution lines of discharge waste plume, winter months SW current (Q = 500 gpm, Vfall = 0.01 cm/s Ua = o.4 kt). If dumping were to take place at the NE periphery under these conditions the plume would be dissipated within the dumpsite circle.

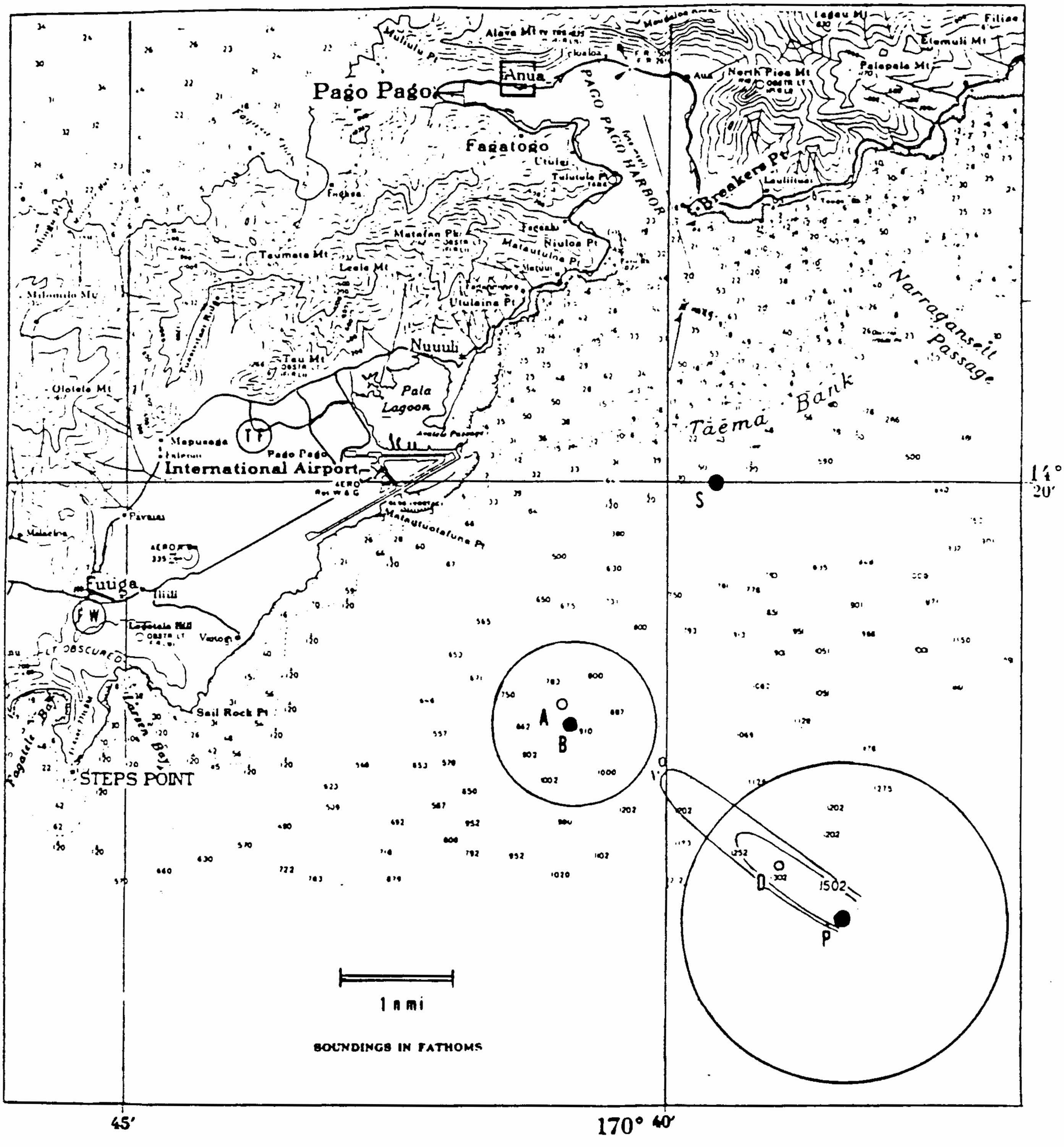

Figure 3-16. The worst-case illustration of the direction of the plume without the SW current. The 250, 000 dilution is reached before the plume reaches territorial waters. Equi-dilution lines of discharge waste plume, summer months NW current (Q = gpm, Vfall = 0.01 cm/s, Ua = 0.2 kt). If dumping were to begin at the SE periphery of the circle, the plume would be dissipated within the dumpsite circle.

current that generally flows southwest between the 120 fm and 600 fm contours. Even if a slick persisted on the surface it would generally be carried farther out to sea to the southwest and could not approach shallow waters.

4. CONCLUSION AND RECOMMENDATION

The results presented in this study are computed by a mathematical model of which the accuracy is dependent on the available data. Whenever the required data are not available, assumptions have been made for the parameters. We have used our best judgment in the estimation of the parameters. We believe that the results obtained by this mathematical model are at least as good as those obtained by any model using the present state of the knowledge.

The present mathematical model predicts the dilution as a function of distance and time from the point of release if the current direction is specified. The extent of the plume has also been shown under various conditions. A key factor in the determination of the plume trajectory is the direction of the ocean current. Field measurements indicate two persistent current directions, SW direction and NW direction. For current going towards the SW direction, it is shown that the plume at the present site will be advected in that direction at a distance at least 2 n mi south of Sail Rock Point. For current in the NW direction, significant dilution has been achieved when the plume reaches the region of shallower depth. Therefore, the longshore current is expected to carry such diluted plume again in SW direction (along the island shoreline direction). More definitive current, information especially on the incidence of reversal of the longshore current in the shallower depth region would be needed in order to predict the extent of the plume in the shallow depth region if the present site were to continue to be used.

By using the preferred deepwater site, and by dumping upstream of the direction of flow, the plume would be fully dissipated within the dumpsite circle in most cases. The plume would not reach territorial waters, the longshore current, or the reefs.

If there is significant change in vessel size or in quantities dumped, the model should be run again to determine the nature of the plume trajectory and extent. A small change in vessel beam is not considered significant.

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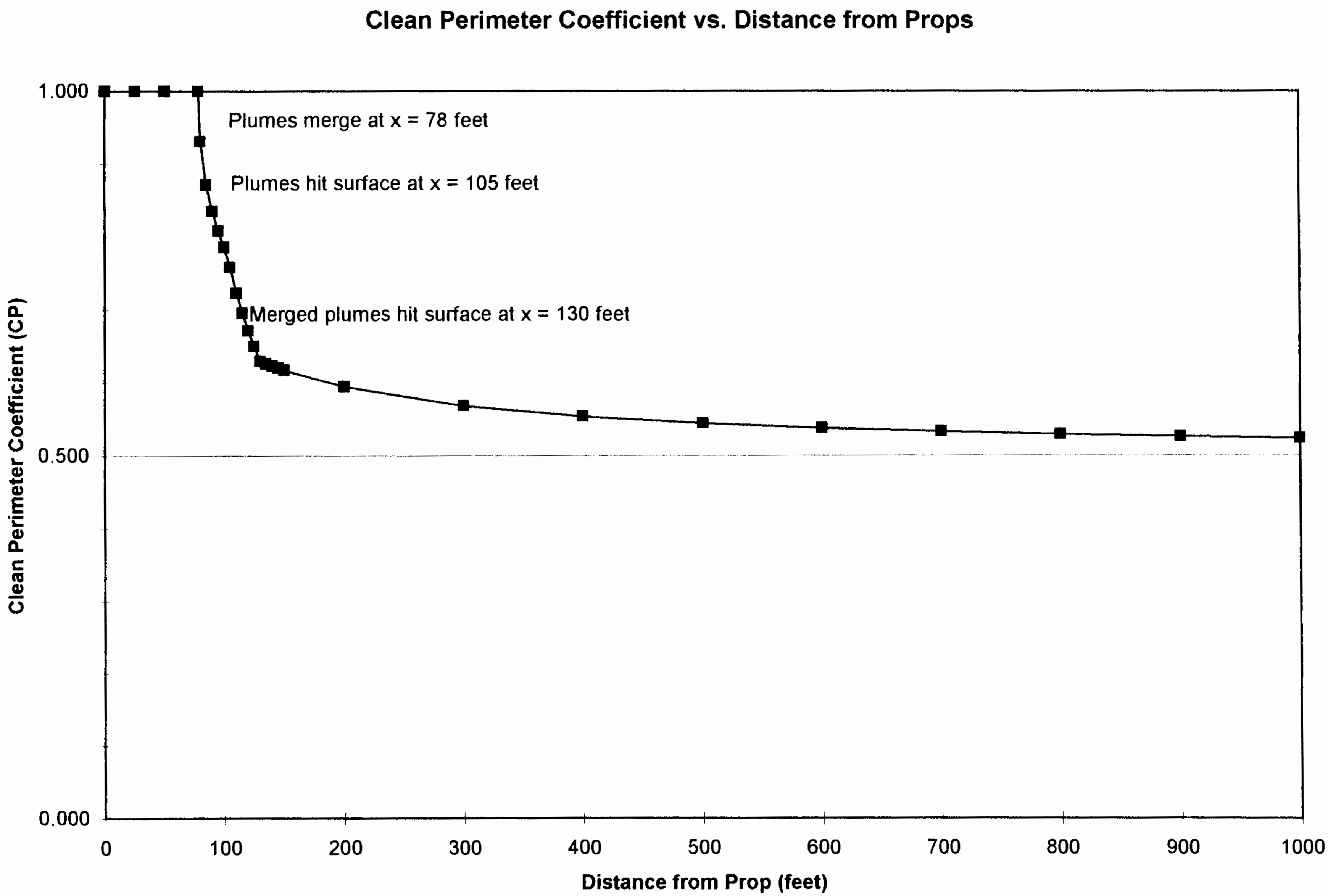
Appendix 9
Calculation of Entrainment Adjustment

Contents of Appendix 9:

- Plot of Clean Perimeter Coefficient vs Distance From Props
- Figure showing Plumes From Adjacent Propellers with Surface Boundary
- Table showing Calculation of Clean Perimeter Ratio



Clean Perimeter Coefficient vs. Distance from Props
Plumes merge at x = 78 feet
Plumes hit surface at x = 105 feet
Merged plumes hit surface at x = 130 feet
1.000
0.500
0.000
0
100
200
300
400
500
600
700
800
900
1000
Clean Perimeter Coefficient (CP)
Distance from Prop (feet)

Plumes from Adjacent Propellers - with Surface Boundary

caled by the ratio of the perimeter inside the adjacent plume to the total perimeter available for entrainment.

hereby defined as the clean perimeter coefficient (CP).

rainment is uniform over the perimeter of the plume. Propellers located 15 feet apart and 10 feet below water surface.

s calculated as r = 0.096X, where X is the distance downstream of the props.

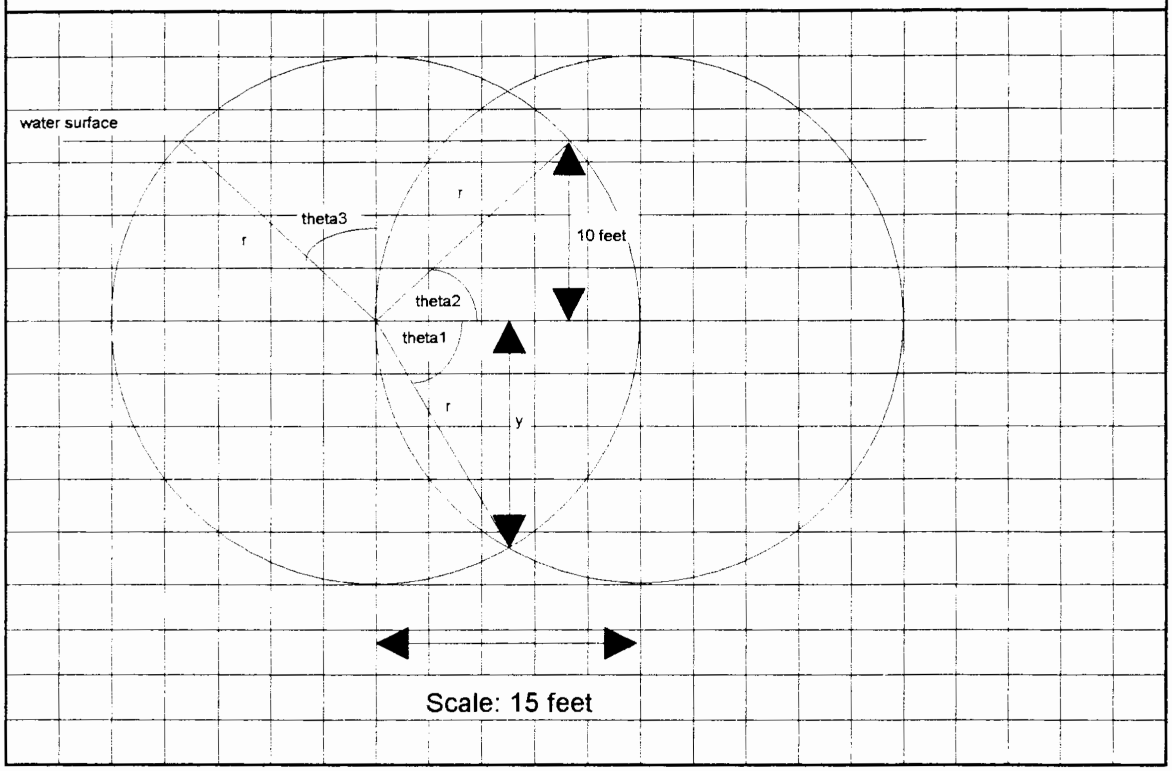
eter coefficient develops in four distinct steps based on plume radius r.

umes merge, CP = 1.0, as the plumes have not interferred with each other. [X<78.125 feet]

plumes merge but before the tops of theindividual plumes hit the surface. [78.125<X<105 feet]

individual plumes hit the surface, but before the merged area hits the surface. [105<X<130 feet]

merged area hits the surface. [130<X]



Calculation of the Clean Perimeter Ratio

Assumptions and Basis for Calculation:
plume half-width b = 0.096*X from Sobey, 1994
X ranges from 25 to 1000 feet
plumes merge at X = 78.125 feet
at 78.125 feet clean perimeter ratio = 1.0
individual plume encounters surface at X = 105 feet
merged plume reaches surface at X = 130 feet

X	b	y	theta1		theta2		theta3		Perimeter (in)	Perimeter (out)	clean ratio
(feet)	(feet)	(feet)	(rad)	(deg)	(rad)	(deg)	(rad)	(deg)	(feet)	(feet)	
0	0.0										1.000
25	2.4										1.000
50	4.8										1.000
78.125	7.5	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0	47.1	1.000
80	7.7	1.7	0.22	12.4	0.22	12.4	0.00	0.0	3.3	44.9	0.931
85	8.2	3.2	0.40	23.2	0.40	23.2	0.00	0.0	6.6	44.7	0.871
90	8.6	4.3	0.52	29.8	0.52	29.8	0.00	0.0	9.0	45.3	0.835
95	9.1	5.2	0.61	34.7	0.61	34.7	0.00	0.0	11.0	46.3	0.807
100	9.6	6.0	0.67	38.6	0.67	38.6	0.00	0.0	12.9	47.4	0.785
105	10.1	6.7	0.73	41.9	0.73	41.9	0.13	7.2	14.8	46.0	0.757
110	10.6	7.4	0.78	44.7	0.78	44.7	0.33	18.7	16.5	42.9	0.723
115	11.0	8.1	0.82	47.2	0.82	47.2	0.44	25.1	18.2	41.5	0.695
120	11.5	8.7	0.86	49.4	0.86	49.4	0.52	29.8	19.9	40.6	0.671
125	12.0	9.4	0.90	51.3	0.90	51.3	0.59	33.6	21.5	39.8	0.650
130	12.5	10.0	0.93	53.1	0.93	53.1	0.64	36.7	23.1	39.3	0.630
135	13.0	10.6	0.95	54.6	0.88	50.5	0.69	39.5	23.8	39.8	0.626
140	13.4	11.2	0.98	56.1	0.84	48.1	0.73	41.9	24.4	40.3	0.623
145	13.9	11.7	1.00	57.4	0.80	45.9	0.77	44.1	25.1	40.9	0.620
150	14.4	12.3	1.02	58.6	0.77	44.0	0.80	46.0	25.8	41.6	0.617
200	19.2	17.7	1.17	67.0	0.55	31.4	1.02	58.6	33.0	48.4	0.595
300	28.8	27.8	1.31	74.9	0.35	20.3	1.22	69.7	47.9	63.0	0.568
400	38.4	37.7	1.37	78.7	0.26	15.1	1.31	74.9	62.9	78.0	0.554
500	48.0	47.4	1.41	81.0	0.21	12.0	1.36	78.0	77.9	93.0	0.544
600	57.6	57.1	1.44	82.5	0.17	10.0	1.40	80.0	93.0	108.1	0.537
700	67.2	66.8	1.46	83.6	0.15	8.6	1.42	81.4	108.1	123.1	0.533
800	76.8	76.4	1.47	84.4	0.13	7.5	1.44	82.5	123.2	138.2	0.529
900	86.4	86.1	1.48	85.0	0.12	6.6	1.45	83.4	138.2	153.2	0.526
1000	96.0	95.7	1.49	85.5	0.10	6.0	1.47	84.0	153.3	168.3	0.523

The inside perimeter is equal to (theta 1 + theta 2) times the radius of the plume:

$$p(in) = (\Theta_1 + \Theta_2)r$$

The outside perimeter is equal to (2 pi - 2 theta 3 - theta 1 - theta 2) times the radius of the plume:

$$p(out) = (2\pi - 2\Theta_3 - \Theta_1 - \Theta_2)r$$

The clean perimeter coefficient (CP) is equal to 1 minus the inside perimeter divided by the sum of the inside and the outside perimeters:

$$CP = 1 - \frac{p(in)}{p(in) + p(out)}$$

Appendix 10
Farfield Model Output

Contents of Appendix 10:

Farfield Dilution Model Output

- Winter Conditions, Ocean Current 0.2 knots, Vessel Speed 10 knots
- Winter Conditions, Ocean Current 0.4 knots, Vessel Speed 10 knots
- Winter Conditions, Ocean Current 0.6 knots, Vessel Speed 10 knots
- Winter Conditions, Ocean Current 0.8 knots, Vessel Speed 10 knots
- Winter Conditions, Ocean Current 1.0 knots, Vessel Speed 10 knots

- Winter Conditions, Ocean Current 0.2 knots, Vessel Speed 6 knots
- Winter Conditions, Ocean Current 0.4 knots, Vessel Speed 6 knots
- Winter Conditions, Ocean Current 0.6 knots, Vessel Speed 6 knots
- Winter Conditions, Ocean Current 0.8 knots, Vessel Speed 6 knots
- Winter Conditions, Ocean Current 1.0 knots, Vessel Speed 6 knots

- Summer Surface Conditions, Ocean Current 0.2 knots, Vessel Speed 10 knots
- Summer Surface Conditions, Ocean Current 0.4 knots, Vessel Speed 10 knots
- Summer Surface Conditions, Ocean Current 0.6 knots, Vessel Speed 10 knots
- Summer Surface Conditions, Ocean Current 0.8 knots, Vessel Speed 10 knots
- Summer Surface Conditions, Ocean Current 1.0 knots, Vessel Speed 10 knots

- Summer Surface Conditions, Ocean Current 0.2 knots, Vessel Speed 6 knots
- Summer Surface Conditions, Ocean Current 0.4 knots, Vessel Speed 6 knots
- Summer Surface Conditions, Ocean Current 0.6 knots, Vessel Speed 6 knots
- Summer Surface Conditions, Ocean Current 0.8 knots, Vessel Speed 6 knots
- Summer Surface Conditions, Ocean Current 1.0 knots, Vessel Speed 6 knots

Farfield Dilution Model

Winter Conditions - Ocean Current 0.2 knots - Vessel Speed 10 knots

Discharge Rate of Waste , in gpm (Q)
1400 (gpm)

Diffusion Coefficient (Kv)
17.3 (cm^2/sec)

Ship's Beam
11.58 (m)

Ship's Draft
3.66 (m)

Ambient Ocean Current, in knots (U)
0.2 (knots)

Dissipation Parameter (A)
0.001

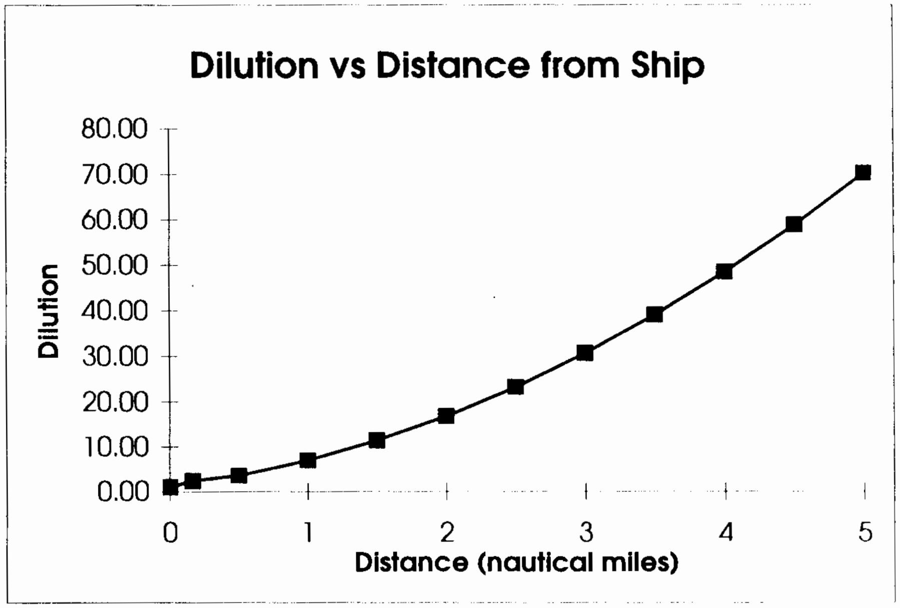
Ship's Length
50 (m)

Ship's Speed, in knots
10 (knots)

Length Parameter, in meters (L)
741 (m)

Initial Concentration
1

Distance from Ship (Feet)	(Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	1.4	0.42	0.42	2.41
3040	0.5	2.5	0.28	0.28	3.59
6080	1	5.0	0.14	0.14	7.01
9120	1.5	7.5	0.09	0.09	11.43
12160	2	10.0	0.06	0.06	16.85
15200	2.5	12.5	0.04	0.04	23.26
18240	3	15.0	0.03	0.03	30.66
21280	3.5	17.5	0.03	0.03	39.06
24320	4	20.0	0.02	0.02	48.46
27360	4.5	22.5	0.02	0.02	58.86
30400	5	25.0	0.01	0.01	70.25



Farfield Dilution Model

Winter Conditions - Ocean Current 0.4 knots - Vessel Speed 10 knots

Discharge Rate of Waste , in gpm (Q): 1400 (gpm)

Diffusion Coefficient (Kv): 17.3 (cm^2/sec)

Ship's Beam: 11.58 (m)

Ship's Draft: 3.66 (m)

Ambient Ocean Current, in knots (U): 0.4 (knots)

Dissipation Parameter (A): 0.001

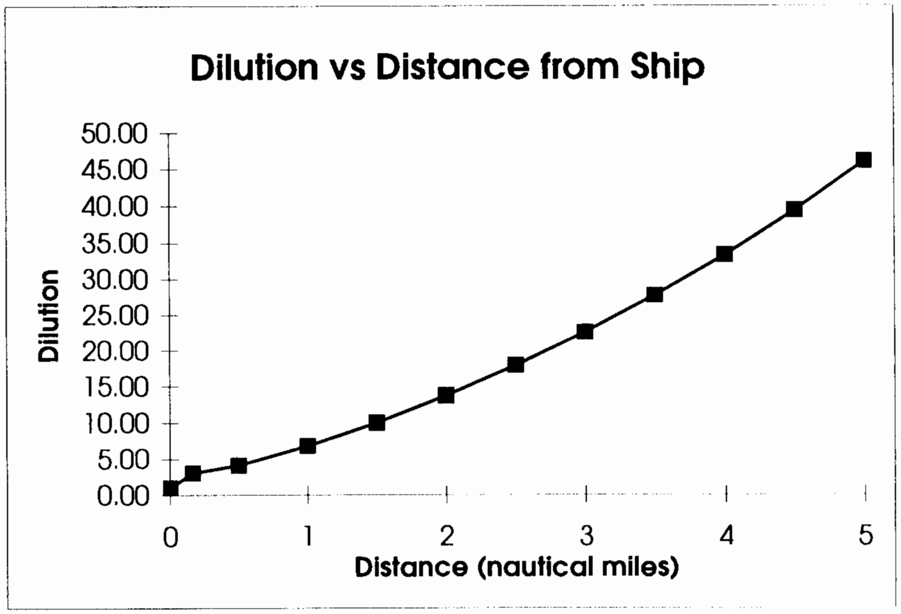
Ship's Length: 50 (m)

Ship's Speed, in knots: 10 (knots)

Length Parameter, in meters (L): 741 (m)

Initial Concentration: 1

Distance from Ship (Feet)	(Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.7	0.33	0.33	3.07
3040	0.5	1.3	0.24	0.24	4.18
6080	1	2.5	0.15	0.15	6.86
9120	1.5	3.8	0.10	0.10	10.03
12160	2	5.0	0.07	0.07	13.69
15200	2.5	6.3	0.06	0.06	17.85
18240	3	7.5	0.04	0.04	22.50
21280	3.5	8.8	0.04	0.04	27.65
24320	4	10.0	0.03	0.03	33.29
27360	4.5	11.3	0.03	0.03	39.43
30400	5	12.5	0.02	0.02	46.06



Farfield Dilution Model

Winter Conditions - Ocean Current 0.6 knots - Vessel Speed 10 knots

Discharge Rate of Waste , in gpm (Q)
1400 (gpm)

Diffusion Coefficient (Kv)
17.3 (cm^2/sec)

Ship's Beam
11.58 (m)

Ship's Draft
3.66 (m)

Ambient Ocean Current, in knots (U)
0.6 (knots)

Dissipation Parameter (A)
0.001

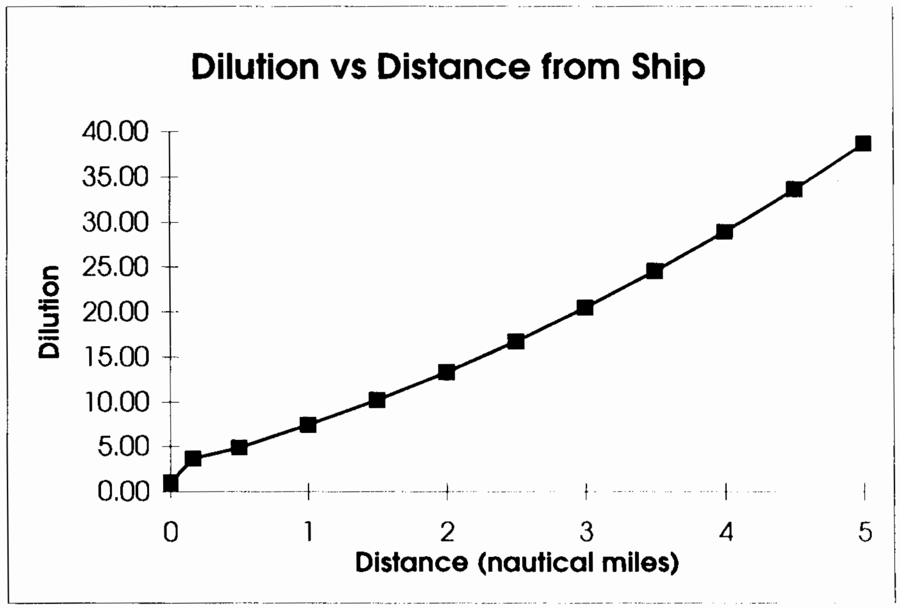
Ship's Length
50 (m)

Ship's Speed, in knots
10 (knots)

Length Parameter, in meters (L)
741 (m)

Initial Concentration
1

Distance from Ship (Feet)	(Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.5	0.27	0.27	3.68
3040	0.5	0.8	0.20	0.20	4.90
6080	1	1.7	0.13	0.13	7.44
9120	1.5	2.5	0.10	0.10	10.20
12160	2	3.3	0.08	0.08	13.29
15200	2.5	4.2	0.06	0.06	16.70
18240	3	5.0	0.05	0.05	20.45
21280	3.5	5.8	0.04	0.04	24.52
24320	4	6.7	0.03	0.03	28.92
27360	4.5	7.5	0.03	0.03	33.65
30400	5	8.3	0.03	0.03	38.71

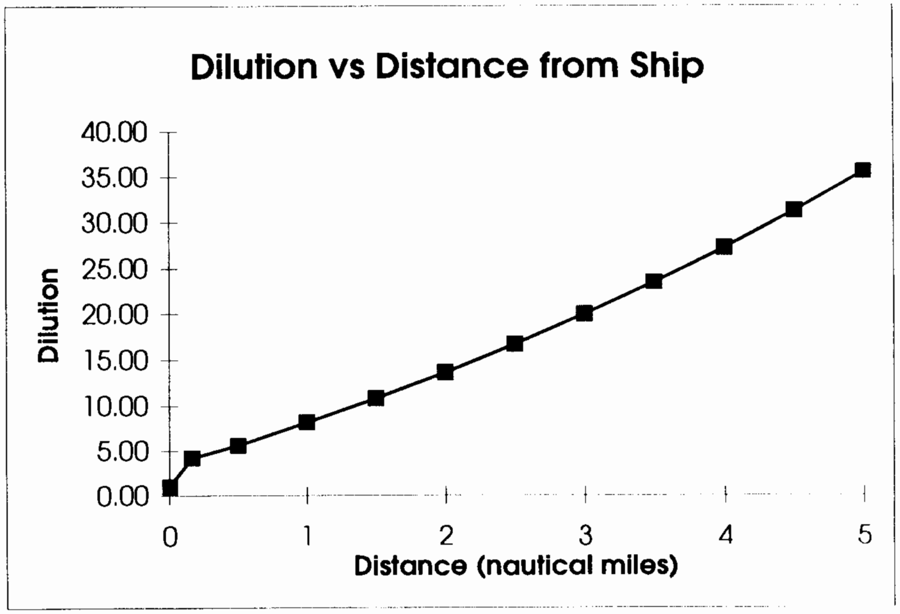


Farfield Dilution Model

Winter Conditions - Ocean Current 0.8 knots - Vessel Speed 10 knots

Discharge Rate of Waste , in gpm (Q) 1400 (gpm)	Diffusion Coefficient (Kv) 17.3 (cm^2/sec)	Ship's Beam 11.58 (m)	Ship's Draft 3.66 (m)
Ambient Ocean Current, in knots (U) 0.8 (knots)	Dissipation Parameter (A) 0.001	Ship's Length 50 (m)	Ship's Speed, in knots 10 (knots)
Length Parameter, in meters (L) 741 (m)	Initial Concentration 1		

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.3	0.24	0.24	4.20
3040	0.5	0.6	0.18	0.18	5.58
6080	1	1.3	0.12	0.12	8.16
9120	1.5	1.9	0.09	0.09	10.75
12160	2	2.5	0.07	0.07	13.56
15200	2.5	3.1	0.06	0.06	16.61
18240	3	3.8	0.05	0.05	19.90
21280	3.5	4.4	0.04	0.04	23.44
24320	4	5.0	0.04	0.04	27.22
27360	4.5	5.6	0.03	0.03	31.25
30400	5	6.3	0.03	0.03	35.52

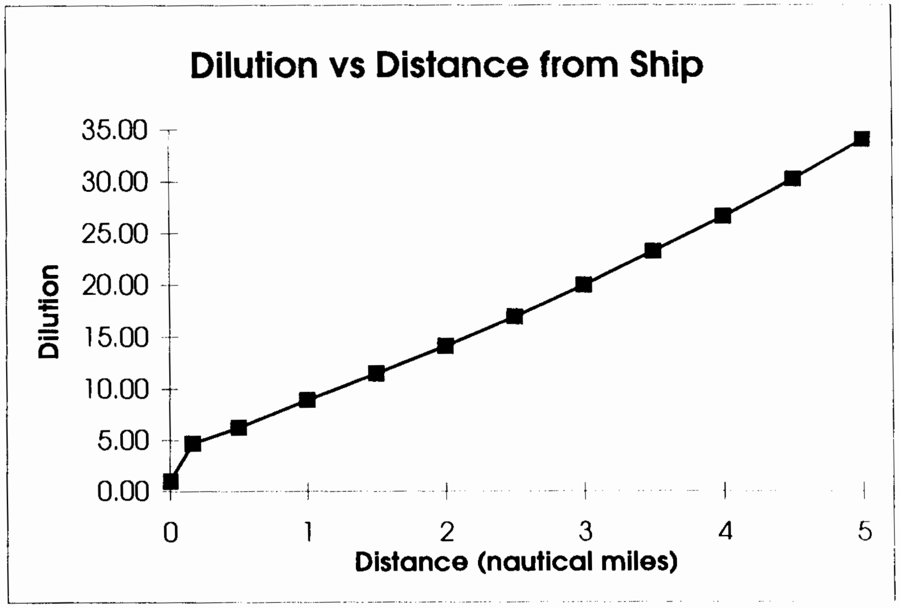


Farfield Dilution Model

Winter Conditions - Ocean Current 1.0 knots - Vessel Speed 10 knots

Discharge Rate of Waste , in gpm (Q)	Diffusion Coefficient (Kv)	Ship's Beam	Ship's Draft
1400 (gpm)	17.3 (cm^2/sec)	11.58 (m)	3.66 (m)
Ambient Ocean Current, in knots (U)	Dissipation Parameter (A)	Ship's Length	Ship's Speed, in knots
1 (knots)	0.001	50 (m)	10 (knots)
Length Parameter, in meters (L)	Initial Concentration		
741 (m)	1		

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.3	0.21	0.21	4.67
3040	0.5	0.5	0.16	0.16	6.21
6080	1	1.0	0.11	0.11	8.90
9120	1.5	1.5	0.09	0.09	11.44
12160	2	2.0	0.07	0.07	14.10
15200	2.5	2.5	0.06	0.06	16.93
18240	3	3.0	0.05	0.05	19.95
21280	3.5	3.5	0.04	0.04	23.17
24320	4	4.0	0.04	0.04	26.58
27360	4.5	4.5	0.03	0.03	30.19
30400	5	5.0	0.03	0.03	34.00



Farfield Dilution Model

Winter Conditions - Ocean Current 0.2 knots - Vessel Speed 6 knots

Discharge Rate of Waste , in gpm (Q)
1400 (gpm)

Ambient Ocean Current, in knots (U)
0.2 (knots)

Length Parameter, in meters (L)
741 (m)

Diffusion Coefficient (Kv)
17.3 (cm^2/sec)

Dissipation Parameter (A)
0.001

Initial Concentration
1

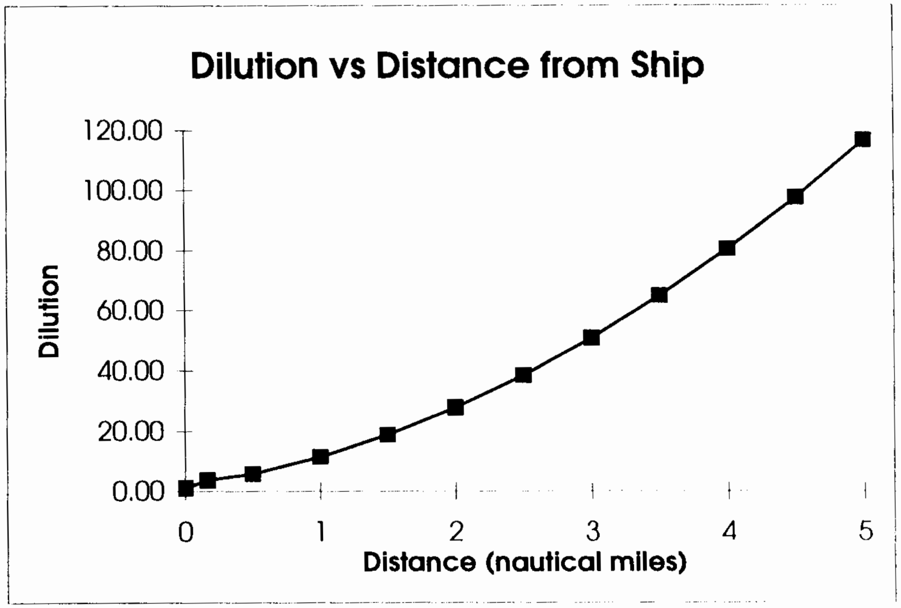
Ship's Beam
11.58 (m)

Ship's Length
50 (m)

Ship's Draft
3.66 (m)

Ship's Speed, in knots
6 (knots)

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	1.4	0.27	0.27	3.76
3040	0.5	2.5	0.17	0.17	5.76
6080	1	5.0	0.09	0.09	11.45
9120	1.5	7.5	0.05	0.05	18.80
12160	2	10.0	0.04	0.04	27.79
15200	2.5	12.5	0.03	0.03	38.44
18240	3	15.0	0.02	0.02	50.75
21280	3.5	17.5	0.02	0.02	64.72
24320	4	20.0	0.01	0.01	80.35
27360	4.5	22.5	0.01	0.01	97.63
30400	5	25.0	0.01	0.01	116.58

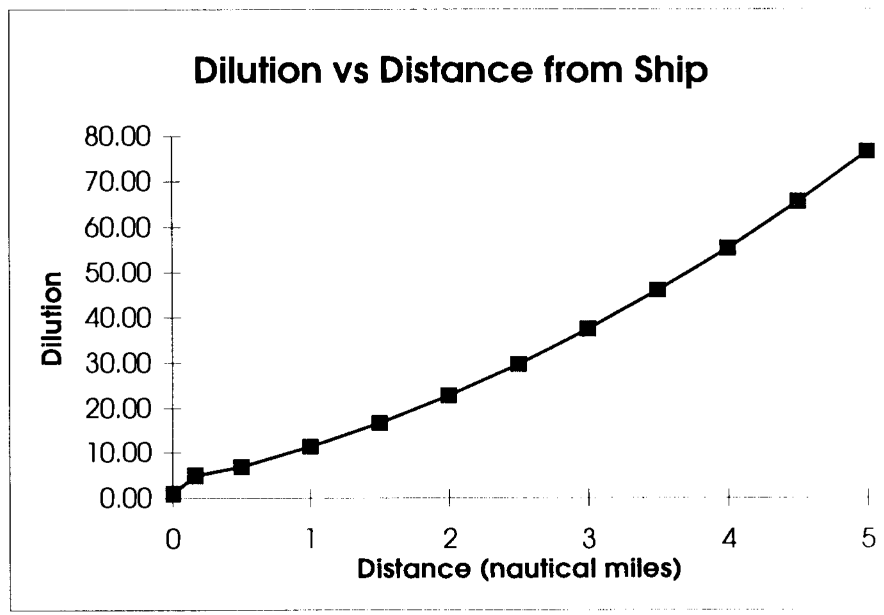


Farfield Dilution Model

Winter Conditions - Ocean Current 0.4 knots - Vessel Speed 6 knots

Parameter	Value	Unit
Discharge Rate of Waste , in gpm (Q)	1400	(gpm)
Diffusion Coefficient (Kv)	17.3	(cm^2/sec)
Ship's Beam	11.58	(m)
Ship's Draft	3.66	(m)
Ambient Ocean Current, in knots (U)	0.4	(knots)
Dissipation Parameter (A)	0.001	
Ship's Length	50	(m)
Ship's Speed, in knots	6	(knots)
Length Parameter, in meters (L)	741	(m)
Initial Concentration	1	

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.7	0.20	0.20	4.94
3040	0.5	1.3	0.15	0.15	6.82
6080	1	2.5	0.09	0.09	11.32
9120	1.5	3.8	0.06	0.06	16.60
12160	2	5.0	0.04	0.04	22.70
15200	2.5	6.3	0.03	0.03	29.62
18240	3	7.5	0.03	0.03	37.37
21280	3.5	8.8	0.02	0.02	45.94
24320	4	10.0	0.02	0.02	55.33
27360	4.5	11.3	0.02	0.02	65.56
30400	5	12.5	0.01	0.01	76.61

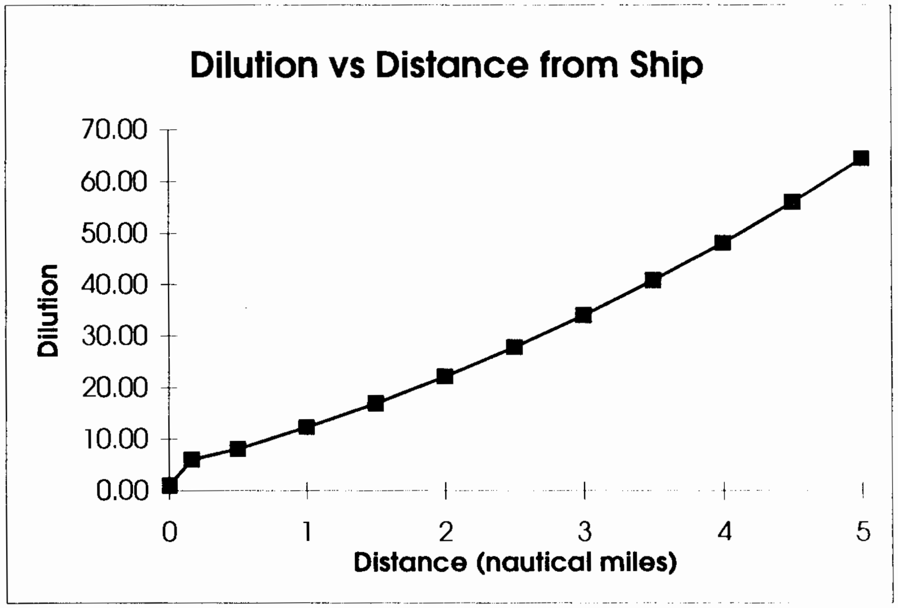


Farfield Dilution Model

Winter Conditions - Ocean Current 0.6 knots - Vessel Speed 6 knots

Discharge Rate of Waste , in gpm (Q)	Diffusion Coefficient (Kv)	Ship's Beam	Ship's Draft
1400 (gpm)	17.3 (cm^2/sec)	11.58 (m)	3.66 (m)
Ambient Ocean Current, in knots (U)	Dissipation Parameter (A)	Ship's Length	Ship's Speed, in knots
0.6 (knots)	0.001	50 (m)	6 (knots)
Length Parameter, in meters (L)	Initial Concentration		
741 (m)	1		

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.5	0.17	0.17	5.98
3040	0.5	0.8	0.12	0.12	8.05
6080	1	1.7	0.08	0.08	12.31
9120	1.5	2.5	0.06	0.06	16.93
12160	2	3.3	0.05	0.05	22.07
15200	2.5	4.2	0.04	0.04	27.76
18240	3	5.0	0.03	0.03	34.00
21280	3.5	5.8	0.02	0.02	40.78
24320	4	6.7	0.02	0.02	48.11
27360	4.5	7.5	0.02	0.02	55.99
30400	5	8.3	0.02	0.02	64.42

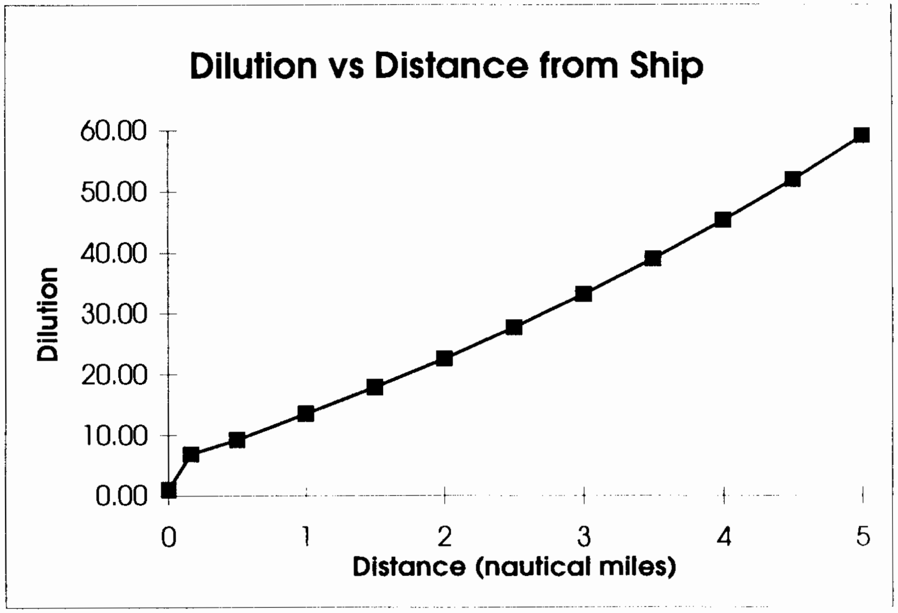


Farfield Dilution Model

Winter Conditions - Ocean Current 0.8 knots - Vessel Speed 6 knots

Discharge Rate of Waste , in gpm (Q) 840 (gpm)	Diffusion Coefficient (Kv) 17.3 (cm^2/sec)	Ship's Beam 11.58 (m)	Ship's Draft 3.66 (m)
Ambient Ocean Current, in knots (U) 0.8 (knots)	Dissipation Parameter (A) 0.001	Ship's Length 50 (m)	Ship's Speed, in knots 6 (knots)
Length Parameter, in meters (L) 741 (m)	Initial Concentration 1		

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.3	0.15	0.15	6.88
3040	0.5	0.6	0.11	0.11	9.21
6080	1	1.3	0.07	0.07	13.52
9120	1.5	1.9	0.06	0.06	17.86
12160	2	2.5	0.04	0.04	22.55
15200	2.5	3.1	0.04	0.04	27.62
18240	3	3.8	0.03	0.03	33.11
21280	3.5	4.4	0.03	0.03	39.00
24320	4	5.0	0.02	0.02	45.30
27360	4.5	5.6	0.02	0.02	52.02
30400	5	6.3	0.02	0.02	59.14



Farfield Dilution Model

Winter Conditions - Ocean Current 1.0 knots - Vessel Speed 6knots

Discharge Rate of Waste , in gpm (Q): 840 (gpm)

Ambient Ocean Current, in knots (U): 1 (knots)

Length Parameter, in meters (L): 741 (m)

Diffusion Coefficient (Kv): 17.3 (cm^2/sec)

Dissipation Parameter (A): 0.001

Initial Concentration: 1

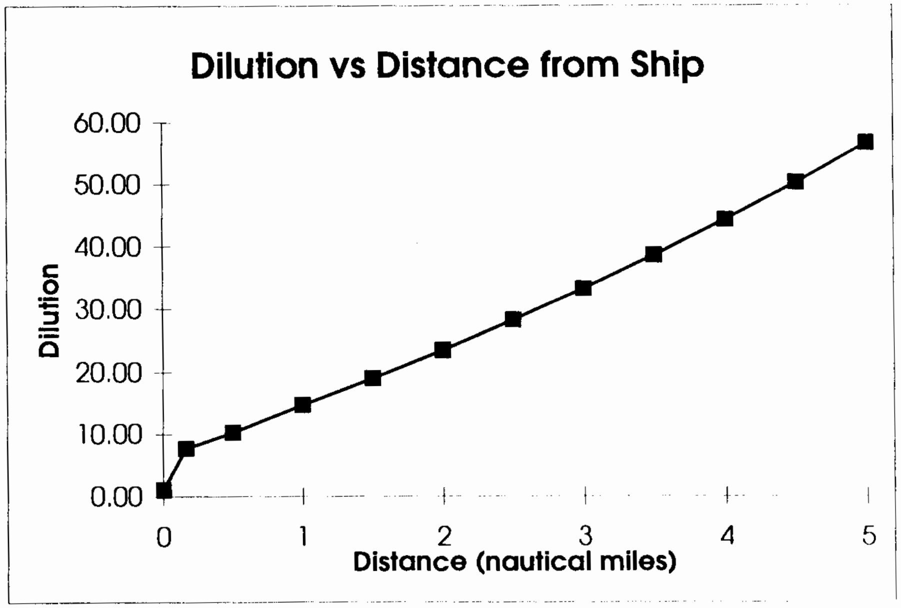
Ship's Beam: 11.58 (m)

Ship's Length: 50 (m)

Ship's Draft: 3.66 (m)

Ship's Speed, in knots: 6 (knots)

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.3	0.13	0.13	7.67
3040	0.5	0.5	0.10	0.10	10.27
6080	1	1.0	0.07	0.07	14.78
9120	1.5	1.5	0.05	0.05	19.01
12160	2	2.0	0.04	0.04	23.44
15200	2.5	2.5	0.04	0.04	28.17
18240	3	3.0	0.03	0.03	33.20
21280	3.5	3.5	0.03	0.03	38.57
24320	4	4.0	0.02	0.02	44.25
27360	4.5	4.5	0.02	0.02	50.27
30400	5	5.0	0.02	0.02	56.61

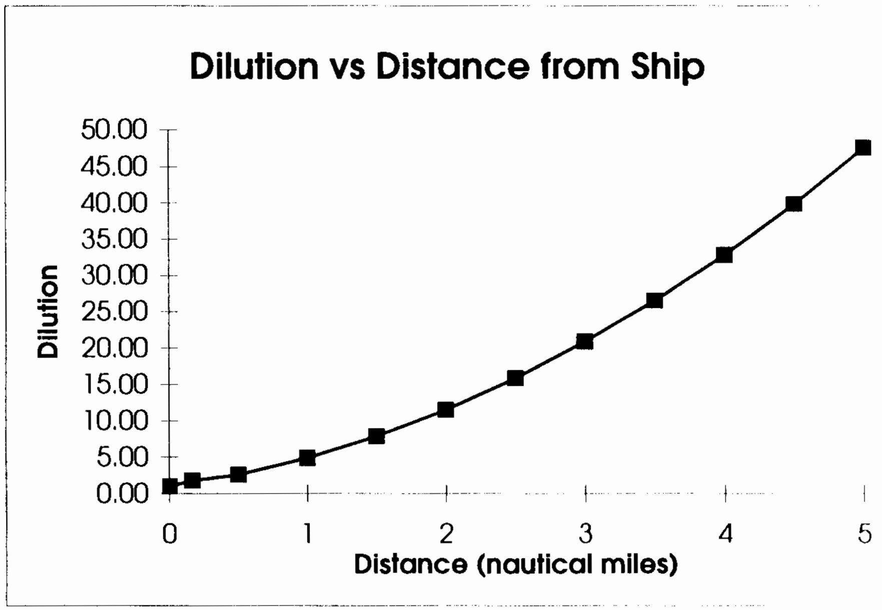


Farfield Dilution Model

Summer Surface Conditions - Ocean Current 0.2 knots - Vessel Speed 10 knots

Parameter	Value	Unit
Discharge Rate of Waste , in gpm (Q)	1200	(gpm)
Ambient Ocean Current, in knots (U)	0.2	(knots)
Length Parameter, in meters (L)	741	(m)
Diffusion Coefficient (Kv)	7.8	(cm^2/sec)
Dissipation Parameter (A)	0.001	
Initial Concentration	1	
Ship's Beam	11.58	(m)
Ship's Length	50	(m)
Ship's Draft	3.66	(m)
Ship's Speed, in knots	10	(knots)

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	1.4	0.56	0.56	1.80
3040	0.5	2.5	0.39	0.39	2.58
6080	1	5.0	0.20	0.20	4.88
9120	1.5	7.5	0.13	0.13	7.87
12160	2	10.0	0.09	0.09	11.53
15200	2.5	12.5	0.06	0.06	15.86
18240	3	15.0	0.05	0.05	20.86
21280	3.5	17.5	0.04	0.04	26.53
24320	4	20.0	0.03	0.03	32.86
27360	4.5	22.5	0.03	0.03	39.87
30400	5	25.0	0.02	0.02	47.54

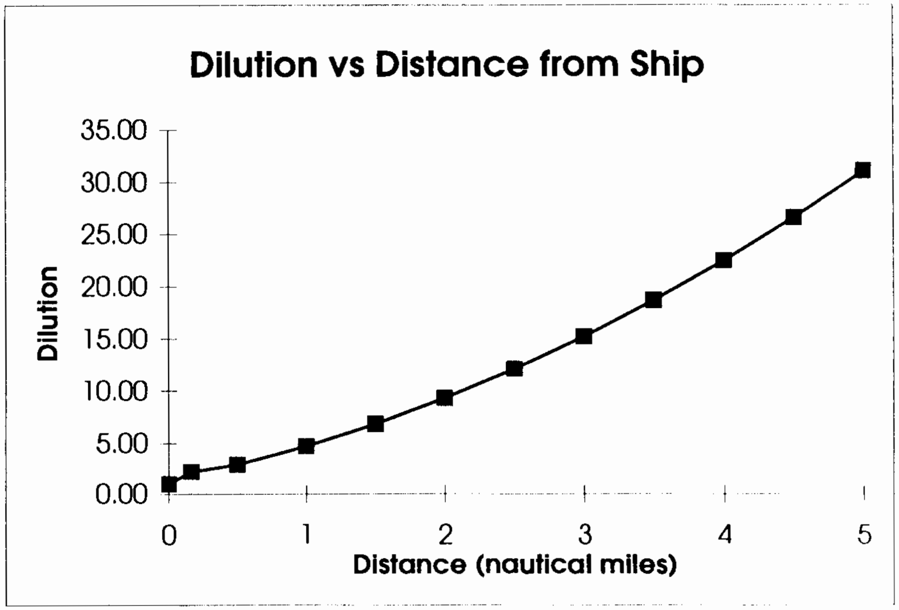


Farfield Dilution Model

Summer Surface Conditions - Ocean Current 0.4 knots - Vessel Speed 10 knots

Discharge Rate of Waste , in gpm (Q)	Diffusion Coefficient (Kv)	Ship's Beam	Ship's Draft
1200 (gpm)	7.8 (cm^2/sec)	11.58 (m)	3.66 (m)
Ambient Ocean Current, in knots (U)	**Dissipation Parameter (A)**	**Ship's Length**	**Ship's Speed, in knots**
0.4 (knots)	0.001	50 (m)	10 (knots)
Length Parameter, in meters (L)	**Initial Concentration**		
741 (m)	1		

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.7	0.46	0.46	2.19
3040	0.5	1.3	0.34	0.34	2.91
6080	1	2.5	0.21	0.21	4.70
9120	1.5	3.8	0.15	0.15	6.82
12160	2	5.0	0.11	0.11	9.29
15200	2.5	6.3	0.08	0.08	12.08
18240	3	7.5	0.07	0.07	15.21
21280	3.5	8.8	0.05	0.05	18.67
24320	4	10.0	0.04	0.04	22.46
27360	4.5	11.3	0.04	0.04	26.59
30400	5	12.5	0.03	0.03	31.05

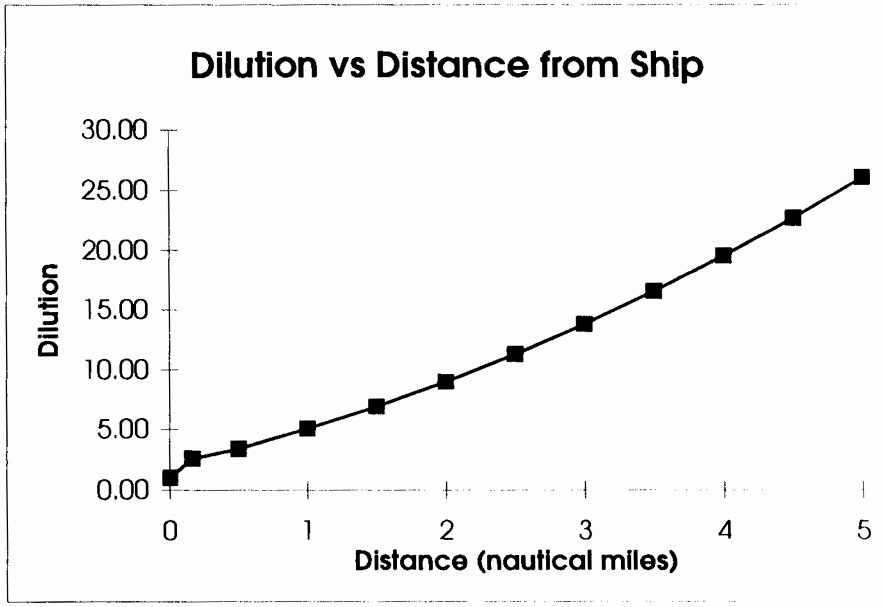


Farfield Dilution Model

Summer Surface Conditions - Ocean Current 0.6 knots - Vessel Speed 10 knots

Discharge Rate of Waste , in gpm (Q)	1200	(gpm)
Ambient Ocean Current, in knots (U)	0.6	(knots)
Length Parameter, in meters (L)	741	(m)
Diffusion Coefficient (Kv)	7.8	(cm^2/sec)
Dissipation Parameter (A)	0.001	
Initial Concentration	1	
Ship's Beam	11.58	(m)
Ship's Length	50	(m)
Ship's Draft	3.66	(m)
Ship's Speed, in knots	10	(knots)

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.5	0.39	0.39	2.58
3040	0.5	0.8	0.30	0.30	3.37
6080	1	1.7	0.20	0.20	5.06
9120	1.5	2.5	0.14	0.14	6.91
12160	2	3.3	0.11	0.11	8.98
15200	2.5	4.2	0.09	0.09	11.28
18240	3	5.0	0.07	0.07	13.79
21280	3.5	5.8	0.06	0.06	16.53
24320	4	6.7	0.05	0.05	19.48
27360	4.5	7.5	0.04	0.04	22.66
30400	5	8.3	0.04	0.04	26.06



Farfield Dilution Model

Summer Surface - Ocean Current 0.8 knots - Vessel Speed 10 knots

Discharge Rate of Waste , in gpm (Q)
1200 (gpm)

Ambient Ocean Current, in knots (U)
0.8 (knots)

Length Parameter, in meters (L)
741 (m)

Diffusion Coefficient (Kv)
7.8 (cm^2/sec)

Dissipation Parameter (A)
0.001

Initial Concentration
1

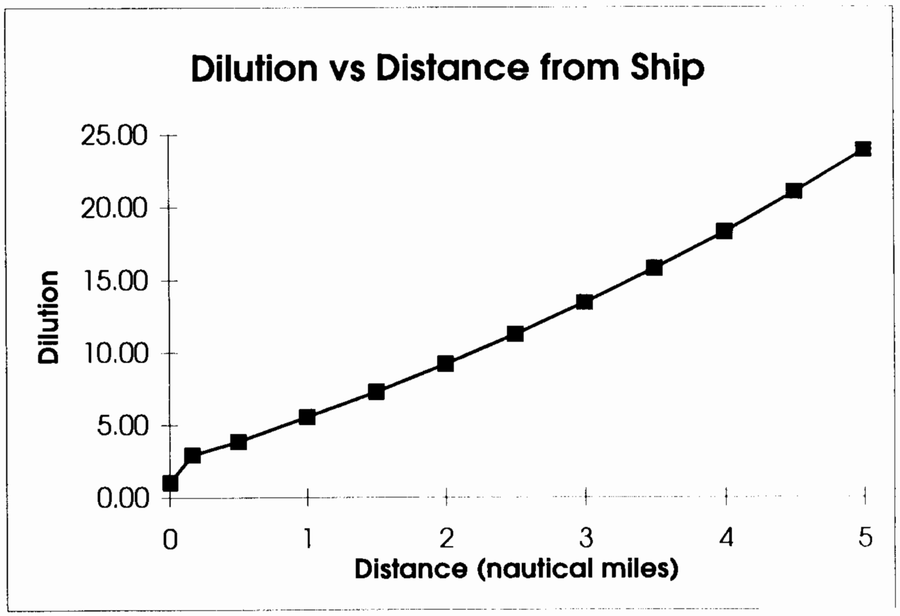
Ship's Beam
11.58 (m)

Ship's Length
50 (m)

Ship's Draft
3.66 (m)

Ship's Speed, in knots
10 (knots)

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.3	0.34	0.34	2.92
3040	0.5	0.6	0.26	0.26	3.82
6080	1	1.3	0.18	0.18	5.53
9120	1.5	1.9	0.14	0.14	7.27
12160	2	2.5	0.11	0.11	9.15
15200	2.5	3.1	0.09	0.09	11.20
18240	3	3.8	0.07	0.07	13.41
21280	3.5	4.4	0.06	0.06	15.78
24320	4	5.0	0.05	0.05	18.32
27360	4.5	5.6	0.05	0.05	21.03
30400	5	6.3	0.04	0.04	23.90

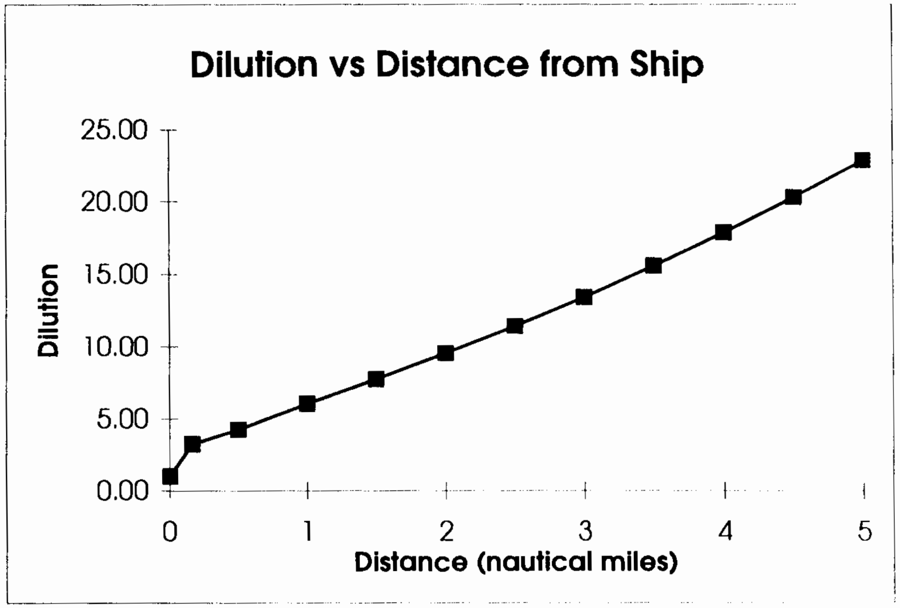


Farfield Dilution Model

Summer Surface Conditions - Ocean Current 1.0 knots - Vessel Speed 10 knots

Discharge Rate of Waste , in gpm (Q) 1200 (gpm)	Diffusion Coefficient (Kv) 7.8 (cm^2/sec)	Ship's Beam 11.58 (m)	Ship's Draft 3.66 (m)
Ambient Ocean Current, in knots (U) 1 (knots)	Dissipation Parameter (A) 0.001	Ship's Length 50 (m)	Ship's Speed, in knots 10 (knots)
Length Parameter, in meters (L) 741 (m)	Initial Concentration 1		

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.3	0.31	0.31	3.22
3040	0.5	0.5	0.24	0.24	4.24
6080	1	1.0	0.17	0.17	6.03
9120	1.5	1.5	0.13	0.13	7.72
12160	2	2.0	0.11	0.11	9.50
15200	2.5	2.5	0.09	0.09	11.40
18240	3	3.0	0.07	0.07	13.43
21280	3.5	3.5	0.06	0.06	15.59
24320	4	4.0	0.06	0.06	17.88
27360	4.5	4.5	0.05	0.05	20.31
30400	5	5.0	0.04	0.04	22.86

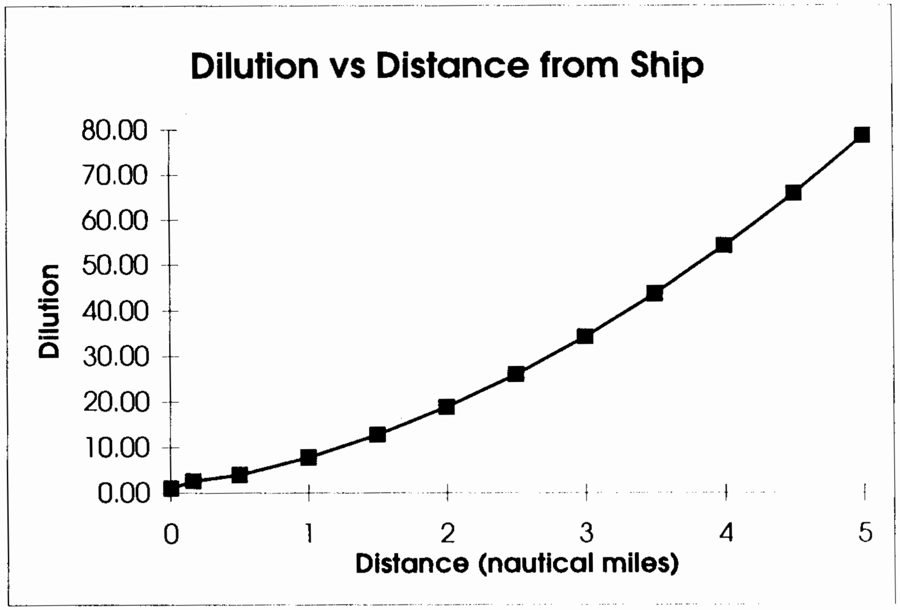


Farfield Dilution Model

Summer Surface Conditions - Ocean Current 0.2 knots - Vessel Speed 6 knots

Discharge Rate of Waste , in gpm (Q)	720	(gpm)
Ambient Ocean Current, in knots (U)	0.2	(knots)
Length Parameter, in meters (L)	741	(m)
Diffusion Coefficient (Kv)	7.8	(cm^2/sec)
Dissipation Parameter (A)	0.001	
Initial Concentration	1	
Ship's Beam	11.58	(m)
Ship's Length	50	(m)
Ship's Draft	3.66	(m)
Ship's Speed, in knots	6	(knots)

Distance from Ship (Feet)	(Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	1.4	0.38	0.38	2.64
3040	0.5	2.5	0.25	0.25	3.97
6080	1	5.0	0.13	0.13	7.80
9120	1.5	7.5	0.08	0.08	12.74
12160	2	10.0	0.05	0.05	18.79
15200	2.5	12.5	0.04	0.04	25.96
18240	3	15.0	0.03	0.03	34.24
21280	3.5	17.5	0.02	0.02	43.64
24320	4	20.0	0.02	0.02	54.14
27360	4.5	22.5	0.02	0.02	65.77
30400	5	25.0	0.01	0.01	78.51

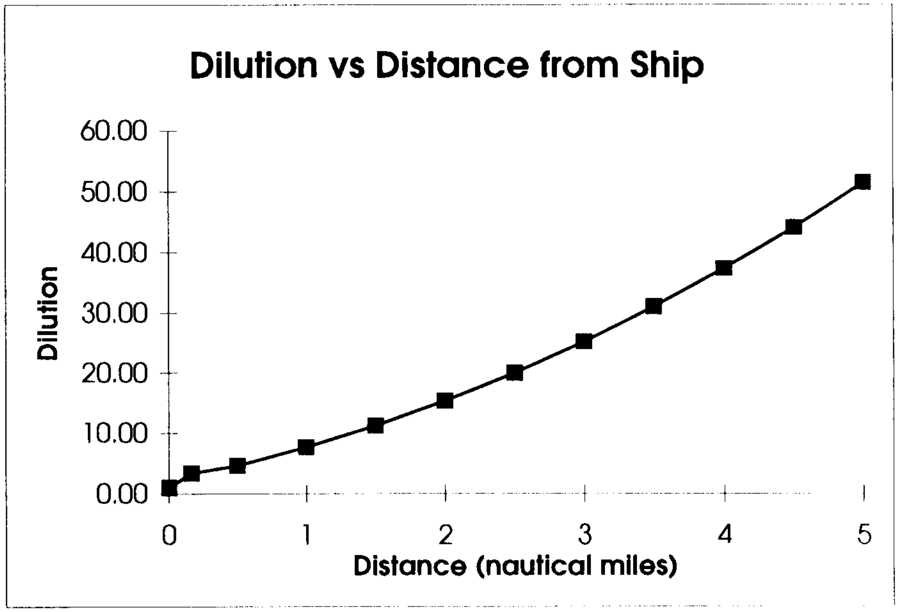


Farfield Dilution Model

Summer Surface Conditions - Ocean Current 0.4 knots - Vessel Speed 6 knots

Discharge Rate of Waste , in gpm (Q)	Diffusion Coefficient (Kv)	Ship's Beam	Ship's Draft
720 (gpm)	7.8 (cm^2/sec)	11.58 (m)	3.66 (m)
Ambient Ocean Current, in knots (U)	**Dissipation Parameter (A)**	**Ship's Length**	**Ship's Speed, in knots**
0.4 (knots)	0.001	50 (m)	6 (knots)
Length Parameter, in meters (L)	**Initial Concentration**		
741 (m)	1		

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.7	0.29	0.29	3.40
3040	0.5	1.3	0.22	0.22	4.65
6080	1	2.5	0.13	0.13	7.66
9120	1.5	3.8	0.09	0.09	11.20
12160	2	5.0	0.07	0.07	15.30
15200	2.5	6.3	0.05	0.05	19.95
18240	3	7.5	0.04	0.04	25.15
21280	3.5	8.8	0.03	0.03	30.91
24320	4	10.0	0.03	0.03	37.22
27360	4.5	11.3	0.02	0.02	44.09
30400	5	12.5	0.02	0.02	51.52



Farfield Dilution Model

Summer Surface Conditions - Ocean Current 0.6 knots - Vessel Speed 6 knots

Discharge Rate of Waste , in gpm (Q)
720 (gpm)

Diffusion Coefficient (Kv)
7.8 (cm^2/sec)

Ship's Beam
11.58 (m)

Ship's Draft
3.66 (m)

Ambient Ocean Current, in knots (U)
0.6 (knots)

Dissipation Parameter (A)
0.001

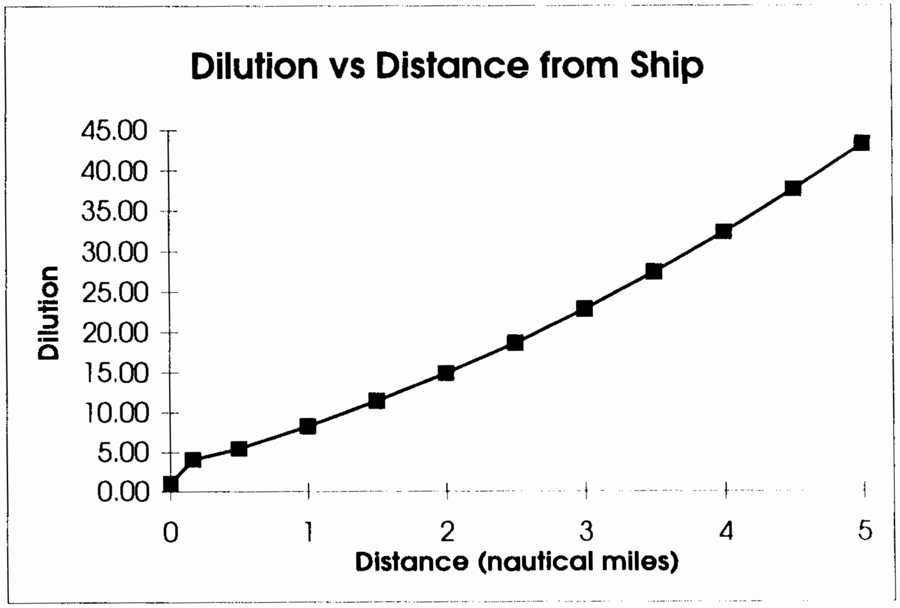
Ship's Length
50 (m)

Ship's Speed, in knots
6 (knots)

Length Parameter, in meters (L)
741 (m)

Initial Concentration
1

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.5	0.24	0.24	4.08
3040	0.5	0.8	0.18	0.18	5.46
6080	1	1.7	0.12	0.12	8.30
9120	1.5	2.5	0.09	0.09	11.40
12160	2	3.3	0.07	0.07	14.86
15200	2.5	4.2	0.05	0.05	18.68
18240	3	5.0	0.04	0.04	22.86
21280	3.5	5.8	0.04	0.04	27.42
24320	4	6.7	0.03	0.03	32.34
27360	4.5	7.5	0.03	0.03	37.64
30400	5	8.3	0.02	0.02	43.30

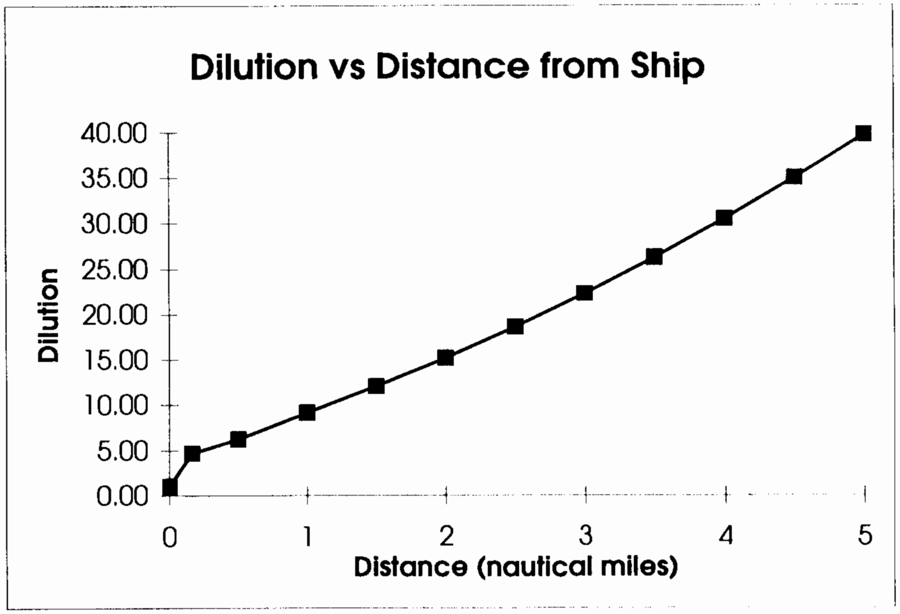


Farfield Dilution Model

Summer Surface Conditions - Ocean Current 0.8 knots - Vessel Speed 6 knots

Discharge Rate of Waste , in gpm (Q)	Diffusion Coefficient (Kv)	Ship's Beam	Ship's Draft
720 (gpm)	7.8 (cm^2/sec)	11.58 (m)	3.66 (m)
Ambient Ocean Current, in knots (U)	**Dissipation Parameter (A)**	**Ship's Length**	**Ship's Speed, in knots**
0.8 (knots)	0.001	50 (m)	6 (knots)
Length Parameter, in meters (L)	**Initial Concentration**		
741 (m)	1		

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.3	0.21	0.21	4.68
3040	0.5	0.6	0.16	0.16	6.23
6080	1	1.3	0.11	0.11	9.11
9120	1.5	1.9	0.08	0.08	12.02
12160	2	2.5	0.07	0.07	15.17
15200	2.5	3.1	0.05	0.05	18.58
18240	3	3.8	0.04	0.04	22.26
21280	3.5	4.4	0.04	0.04	26.21
24320	4	5.0	0.03	0.03	30.45
27360	4.5	5.6	0.03	0.03	34.95
30400	5	6.3	0.03	0.03	39.74



Farfield Dilution Model

Summer Surface Conditions - Ocean Current 1.0 knots - Vessel Speed 6 knots

Discharge Rate of Waste , in gpm (Q)
720 (gpm)

Ambient Ocean Current, in knots (U)
1 (knots)

Length Parameter, in meters (L)
741 (m)

Diffusion Coefficient (Kv)
7.8 (cm^2/sec)

Dissipation Parameter (A)
0.001

Initial Concentration
1

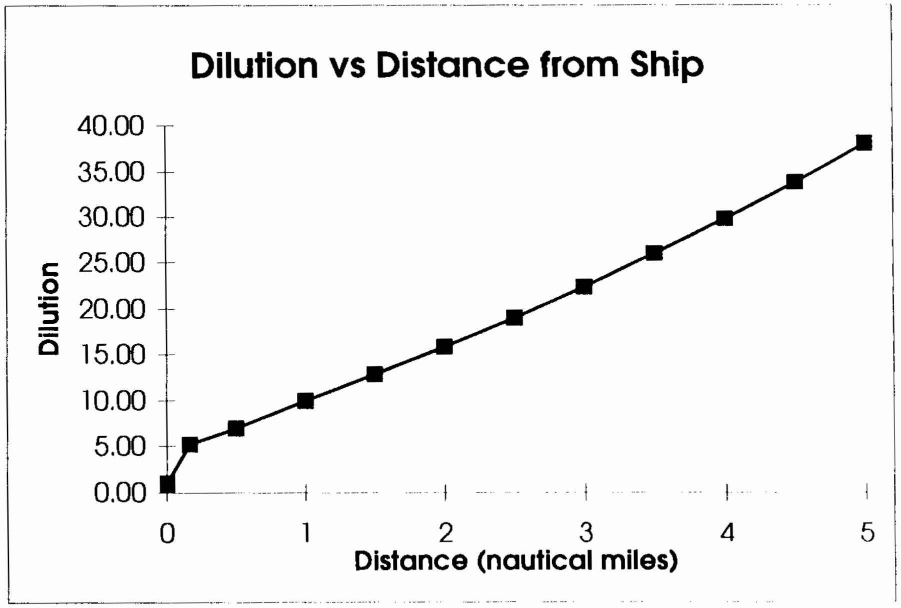
Ship's Beam
11.58 (m)

Ship's Length
50 (m)

Ship's Draft
3.66 (m)

Ship's Speed, in knots
6 (knots)

Distance from Ship (Feet)	Distance from Ship (Nautical Miles)	Time (hours)	Cmax/Co	Cmax	Dilution
0	0	0.0	1.00	1.00	1.00
1000	0.16	0.3	0.19	0.19	5.21
3040	0.5	0.5	0.14	0.14	6.93
6080	1	1.0	0.10	0.10	9.95
9120	1.5	1.5	0.08	0.08	12.79
12160	2	2.0	0.06	0.06	15.76
15200	2.5	2.5	0.05	0.05	18.93
18240	3	3.0	0.04	0.04	22.32
21280	3.5	3.5	0.04	0.04	25.92
24320	4	4.0	0.03	0.03	29.74
27360	4.5	4.5	0.03	0.03	33.78
30400	5	5.0	0.03	0.03	38.04



Appendix 11
Summary of Monitoring Data

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Average Daily Volumes Ocean Disposed

(not including zero disposal days)

September 1993 - September 1996

MONTH/YR	AVERAGE DAILY TOTAL Samoa Packing (gallons)	StarKist Samoa (gallons)	COMBINED (gallons)	VOLUME FRACTION Samoa Packing	StarKist Samoa
Sep-93	83,200	121,094	204,294	0.41	0.59
Oct-93	104,540	106,368	210,909	0.50	0.50
Nov-93	92,208	115,474	207,682	0.44	0.56
Dec-93	92,048	90,682	182,729	0.50	0.50
Jan-94	88,818	97,200	186,018	0.48	0.52
Feb-94	86,760	112,280	199,040	0.44	0.56
Mar-94	105,393	100,792	206,185	0.51	0.49
Apr-94	105,640	99,647	205,287	0.51	0.49
May-94	107,609	100,500	208,109	0.52	0.48
Jun-94	111,650	97,692	209,342	0.53	0.47
Jul-94	89,150	98,913	188,063	0.47	0.53
Aug-94	84,550	95,154	179,704	0.47	0.53
Sep-94	92,600	108,600	201,200	0.46	0.54
Oct-94	104,692	91,409	196,101	0.53	0.47
Nov-94	95,000	105,208	200,208	0.47	0.53
Dec-94	91,964	104,000	195,964	0.47	0.53
Jan-95	102,654	88,864	191,517	0.54	0.46
Feb-95	99,174	102,904	202,078	0.49	0.51
Mar-95	105,000	130,385	235,385	0.45	0.55
Apr-95	97,625	80,333	177,958	0.55	0.45
May-95	93,115	101,670	194,785	0.48	0.52
Jun-95	117,864	105,962	223,825	0.53	0.47
Jul-95	91,542	85,208	176,750	0.52	0.48
Aug-95	93,962	124,826	218,787	0.43	0.57
Sep-95	88,500	117,459	205,959	0.43	0.57
Oct-95	110720	101,250	211,970	0.52	0.48
Nov-95	100,292	100,343	200,634	0.50	0.50
Dec-95	101,952	124,578	226,530	0.45	0.55
Jan-96	101,174	118,285	219,459	0.46	0.54
Feb-96	97,318	112,275	209,593	0.46	0.54
Mar-96	96,231	120,508	216,739	0.44	0.56
Apr-96	118,789	99,917	218,706	0.54	0.46
May-96	78,204	88,331	166,535	0.47	0.53
Jun-96	73,394	89,606	163,000	0.45	0.55
Jul-96	109,337	89,120	198,458	0.55	0.45
Aug-96	123,359	101,266	224,626	0.55	0.45
Sep-96	119,184	85,219	204,403	0.58	0.42
Minimum	73,394	80,333	163,000	0.41	0.42
Maximum	123,359	130,385	235,385	0.58	0.59
Mean	98,790	103,063	201,852	0.49	0.51
Median	97,625	101,250	204,294	0.48	0.52
St. Deviation	11,515	12,427	16,478	0.04	0.04

Samoa Packing Onshore Monitoring
Results of Composite (Storage Tank) Samples
September 1993 - September 1996

DATE	TSS (MG/L)	TVSS (MG/L)	BOD5 (MG/L)	0&G (MG/L)	TP (MG/L)	TN (MG/L)	Ammonia (MG/L)	pH (SU)	Density (G/ML)
8-Sep-93	17300	9920	425000	20588	3500	19040	8400	6.65	0.98
6-Oct-93	6790	897	33500	33370	750	2940	560	7.06	1.02
14-Oct-93	8480	3390	255000	5680	1400	3080	840	6.61	1.01
3-Nov-93	19200	9270	30700	16700	2400	5880	3450	7.39	1.03
9-Nov-93	27500	13900	32000	8520	2100	6160	3480	6.73	1.03
16-Nov-93	17600	8890	27100	14580	2200	7840	6580	6.87	1.00
6-Dec-93	12100	6270	13800	4006	600	4480	1880	6.43	1.02
13-Dec-93	33200	25000	21000	5240	1200	8120	1180	6.28	1.02
4-Jan-94	15600	7170	24400	2460	1000	5880	2650	6.86	1.01
10-Jan-94	7730	2440	13200	10240	1200	5880	1850	6.74	1.02
1-Feb-94	16300	8430	24100	7240	1000	5880	2390	6.93	0.98
7-Feb-94	14500	7050	18000	3700	1000	4760	2000	6.96	1.00
1-Mar-94	11900	5090	19900	1958	600	7280	2290	6.94	1.00
7-Mar-94	9900	2870	20100	17440	800	6160	2500	6.68	0.99
4-Apr-94	12000	5820	18900	19040	1900	5880	2050	7.00	0.98
11-Apr-94	12700	5980	19300	16200	2000	7280	2300	6.72	1.01
2-May-94	5390	1430	11300	9780	1200	1960	1960	7.36	1.01
10-May-94	9350	5940	14400	8880	1200	4760	1590	6.32	0.98
7-Jun-94	33500	27000	350000	28120	1000	4480	2030	6.02	0.99
14-Jun-94	45900	38400	480000	37900	1000	7560	2250	6.16	1.00
5-Jul-94	22000	16400	22500	7212	1000	2800	1220	6.25	1.00
12-Jul-94	64800	55300	54500	28840	700	4480	1440	6.20	1.00
1-Aug-94	72400	59200	73200	5788	1200	3080	2800	6.00	0.99
8-Aug-94	18700	10700	26400	57260	1000	7560	2240	6.02	1.00
6-Sep-94	45300	35300	57800	37660	2400	3920	3370	6.50	1.00
12-Sep-94	86300	72800	99800	19460	1200	4480	3530	6.03	1.00
3-Oct-94	16200	8300	21600	15940	1200	8960	2960	6.00	1.01
25-Oct-94	26000	20000	23300	160000	1200	6160	2170	5.90	0.99
1-Nov-94	22600	10300	24200	919	1700	7280	3340	5.30	1.00
6-Nov-94	24600	15400	20700	1789	1200	7560	3240	5.60	0.99
5-Dec-94	20700	11000	16000	13360	2000	5320	3530	5.40	1.00
12-Dec-94	18400	8850	15600	1161	1500	7560	3930	5.00	1.00

Samoa Packing Onshore Monitoring
Results of Composite (Storage Tank) Samples
September 1993 - September 1996

DATE	TSS (MG/L)	TVSS (MG/L)	BOD5 (MG/L)	0&G (MG/L)	TP (MG/L)	TN (MG/L)	Ammonia (MG/L)	pH (SU)	Density (G/ML)
3-Jan-95	22600	13000	32400	62820	2000	4480	3310	6.70	1.00
13-Jan-95	10000	3190	16500	62000	1000	5320	2800	5.00	1.01
1-Feb-95	12300	3420	20300	68020	1300	7280	3320	6.80	0.99
16-Feb-95	13700	5730	18600	49140	1700	7560	2870	6.70	0.99
1-Mar-95	12600	2170	21000	10460	1200	6160	3720	6.50	1.00
9-Mar-95	16900	7200	39100	7600	1200	4480	2710	6.00	1.01
3-Apr-95	16700	7490	21500	9360	2000	5264	2550	6.80	0.99
13-Apr-95	19300	12200	26600	7600	1200	6348	2690		1.00
1-May-95	24000	16100	36200	11440	1800	5040	2730	6.60	1.00
12-May-95	15700	9500	22900	2240	1300	7840	2420		1.00
1-Jun-95	16100	8690	29100	14780	1000	7840	2340	6.80	0.99
16-Jun-95	15700	7460	27400	15580	700	4760	2050	6.60	0.99
5-Jul-95	15700	7280	19400	404200	1200	6160	2170	6.90	1.00
18-Jul-95	15600	7260	18000	78640	287	7560	2210	7.10	1.00
2-Aug-95	17000	7510	20500	259880	310	7560	2400	6.60	1.00
17-Aug-95	14700	6640	18700	10120	333	8400	2290	6.80	0.99
6-Sep-95	10600	3860	18900		507	8960	2300	6.60	1.00
12-Sep-95	37000	27900	43500	23800	780	17640	2760	6.70	1.00
3-Oct-95	35400	25200	32000	20500	793	8120	2900	7.00	1.00
6-Nov-95	14700	7540	29200	24600	368	5880	2870	6.20	1.00
6-Dec-95	18700	9760	24600	59920	1059	8400	2670	6.60	1.00
3-Jan-96	16600	7860	23900	115060	655	7280	2790	6.50	1.00
1-Feb-96	74300	69400	41300	178560	616	6720	1260	6.70	1.00
4-Mar-96	18200	11900	23100	12468	1287	8960	2150	6.50	1.00
2-Apr-96	22500	13400	27000	97560	984	5880	3080	6.70	1.01
6-May-96	13200	6130	14200	5590	818	5320	1930	7.00	1.01
3-Jun-96	9740	4530	12500	62200	371	5320	1730	6.90	1.00
2-Jul-96	21600	10400	21700	3760	736	5600	2440	6.80	1.00
5-Aug-96	35100	23900	29500	5200	404	3080	2440	7.30	1.00
3-Sep-96	16280	10400	18400	3860	2156	11760	1840	7.00	0.99

No. Samples	62	62	62	61	62	62	62	60	62
Maximum	86300	72800	480000	404200	3500	19040	8400	7.39	1.03
Minimum	5390	897	11300	919	287	1960	560	5.00	0.98
Mean	22217	14125	49279	37836	1200	6539	2609	6.52	1.00
Median	16800	8770	23200	14780	1200	6160	2430	6.67	1.00
St. Dev.	16346	15464	90696	66742	616	2839	1149	0.52	0.01

StarKist Samoa Onshore Monitoring
Results of Composite (Storage Tank) Samples
September 1993 - September 1996

DATE	TSS (mg/L)	TVSS (mg/L)	BOD5 (mg/L)	0&G (mg/L)	TP (mg/L)	TN (mg/L)	Ammonia (mg/L)	pH (SU)	Density (g/ml)
10-Sep-93	20,400	13,500		3,920	252	3,790	1,960	6.89	1.01
28-Oct-93	34,400	19,500	37,800	6,280	87	6,570	8,220	6.95	1.02
3-Nov-93	70,200	51,000	55,400	6,940	115	9,810	10,800	6.70	1.03
17-Nov-93	68,600	45,600	83,900	29,300	670	9,120	7,965	6.54	0.94
19-Nov-93	52,100	33,100	44,900	25,500	552	6,210	9,105	6.80	1.01
10-Dec-93	58,300	45,300	73,527	4,950	651	7,000	4,190	6.86	0.95
17-Dec-93	35,800	20,800	67,247	10,100	502	5,110	3,040	6.50	1.00
21-Jan-94	35,400	17,400	57,425	8,110	526	6,380	4,930	6.93	1.03
28-Jan-94	70,140	52,600	60,958	19,700	1,040	7,850	4,230	6.88	0.99
9-Feb-94	109,000	89,300	73,236	29,800	1,250	7,290	3,690	6.50	0.98
17-Feb-94	50,600	34,300	54,610	14,600	915	7,480	4,140	6.73	1.01
9-Mar-94	50,200	29,200	65,167	4,500	897	1,750	283	6.98	0.97
24-Mar-94	69,900	46,800	112,261	20,100	3,210	14,300	9,700	7.13	0.96
23-May-94	42,100	25,700	58,327	13,669	655	5,120	3,510	6.84	1.02
30-May-94	73,600	58,100	125,375	22,352	1,072	6,900	4,410	6.18	0.97
15-Jun-94	30,600	12,800	67,282	6,535	608	4,940	3,420	6.46	1.02
22-Jun-94	39,100	28,900	38,781	23,013	734	4,600	2,290	6.23	1.00
20-Jul-94	46,600	2,700	103,767	26,415	1,740	7,090	5,200	6.73	0.99
27-Jul-94	36,700	19,600	131,250	14,979	674	5,390	4,470	6.68	1.01
16-Aug-97	150,000	131,000	96,833	51,903	2,530	5,330	1,910	6.52	0.94
25-Aug-94	48,600	35,800	103,072	76,256	1,040	3,180	282	5.47	0.97
20-Sep-94	55,100	38,500	95,483	32,696	1,270	5,190	4,580	6.96	0.98
27-Sep-94	37,100	24,200	102,428	13,433	618	5,120	3,990	6.62	0.99
1-Oct-94	54,200	35,300	95,567	15,008	620	5,540	3,060	6.35	1.00
7-Oct-94	48,200	26,400	96,644	14,123	512	5,040	3,900	6.52	0.99
17-Nov-94	49,700	33,300	66,709	187,779	950	8,290	4,300	6.71	1.01
23-Nov-94	36,700	21,200	66,366	16,179	662	6,150	4,220	6.63	1.01
14-Dec-94	88,900	63,200	99,026	30,084	1,180	5,060	3,390	6.10	1.03
21-Dec-94	137,000	113,000	100,911	61,901	1,110	2,370	295	5.40	1.00

StarKist Samoa Onshore Monitoring
Results of Composite (Storage Tank) Samples
September 1993 - September 1996

DATE	TSS (mg/L)	TVSS (mg/L)	BOD5 (mg/L)	0&G (mg/L)	TP (mg/L)	TN (mg/L)	Ammonia (mg/L)	pH (SU)	Density (g/ml)
27-Jan-95	60,800	44,000	74,889	25,340	789	4,100	4,800	6.40	1.01
31-Jan-95	64,000	4,470	82,339	22,721	1,110	6,660	5,160	6.90	1.01
25-Feb-95	64,300	49,400	95,139	56,793	997	6,660	5,170	6.80	0.99
2-Mar-95	56,300	40,700	101,978	50,204	612	3,940	3,330	6.44	1.01
3-Mar-95	53,600	38,600	106,856	39,360	933	4,500	3,650	6.30	1.00
11-Mar-95	117,000	84,100	94,628	36,286	3,830	4,370	3,720	6.20	1.01
7-Apr-95	61,100	39,300	93,505	40,968	3,100	2,820	2,290	6.40	1.00
13-Apr-95	27,300	20,700	50,893	17,648	361	1,790	1,560	6.60	0.99
3-May-95	79,300	60,300	136,750	31,841	1,400	6,390	434	6.30	1.00
10-May-95	46,400	33,600	111,611	16,791	666	4,820	4,050	6.60	1.00
28-Jun-95	41,500	29,300	63,726	18,098	502	2,807	2,310	6.49	1.01
5-Jul-95	53,200	38,800	113,300	13,526	791	5,570	3,870	6.75	1.01
6-Jul-95	62,600	46,900	95,850	35,005	940	9,640	5,230	6.76	1.00
26-Jul-95	65,700	45,000	67,268	18,619	1,100	5,920	4,470	6.73	1.00
1-Aug-95	60,000	36,800	77,311	13,579	817	6,350	3,990	6.71	1.00
9-Aug-95	32,500	18,600	64,220	9,103	525	3,490	2,990	6.56	0.99
14-Sep-95	46,200	30,800	51,950	5,134	652	3,250	2,910	6.00	1.00
28-Sep-95	42,500	25,000	93,550	10,898	667	4,980	3,060	6.40	1.00
19-Oct-95	86,800	58,000	122,500	14,635	2,200	6,490	3,850	6.50	1.01
27-Oct-95	42,700	27,100	72,289	13,504	626	5,820	4,210	6.50	1.00
15-Nov-95	48,500	26,800	74,089	33,710	691	4,220	3,410	6.60	1.02
28-Nov-95	22,400	10,300	70,686	5,038	609	5,430	3,880	6.70	1.00
19-Dec-95	80,700	61,600	95,661	22,771	1,070	8,120	4,610	6.70	1.04
15-Jan-96	35,200	22,900	60,901	11,239	846	5,010	3,870	6.70	1.00
24-Jan-96	50,300	35,700	62,132	21,240	975	4,330	3,740	6.46	1.00
7-Feb-96	39,900	24,400	63,229	40,929	639	5,020	3,260	6.50	1.00
21-Feb-96	51,800	36,900	64,295	34,066	935	6,720	3,840	6.50	1.01
13-Mar-96	46,900	31,200	75,369	18,090	654	5,550	2,910	6.40	1.00
22-Mar-96	34,100	18,200	68,610	8,526	546	4,930	3,310	6.70	1.01
23-Apr-96	43,700	27,100	79,633	28,399	353	3,400	1,430	6.40	1.00
30-Apr-96	61,500	44,600	73,890	39,266	951	6,360	5,270	6.70	1.00
2-May-96	60,000	40,200	62,077	42,754	866	6,070	4,720	6.60	1.01
15-May-96	64,000	47,400	65,833	21,046	742	7,200	2,980	6.50	1.00
19-Jun-96	109,400	94,200	68,756	49,715	1,290	1,190	5,810	6.70	1.00
27-Jun-96	62,100	43,400	66,239	23,065	1,040	8,250	4,950	6.70	1.00
10-Jul-96	77,200	70,300	69,327	24,258	1,450	8,930	5,070	6.40	1.00
30-Jul-96	81,900	57,800	66,493	31,960	1,430	7,020	1,770	6.70	1.02
7-Aug-96	74,300	47,600	55,259	16,153	906	9,160	4,390	6.60	1.01
28-Aug-96	59,400	44,200	58,049	22,319	811	6,170	3,140	7.00	1.00
5-Sep-96	79,600	63,400	57,818	25,354	981	8,290	4,550	6.80	1.00
19-Sep-96	92,600	70,500	55,617	27,124	902	6,850	4,970	6.60	1.02

No. Samples	70	70	69	70	70	70	70	70	70
Maximum	150000	131000	136750	187779	3830	14300	10800	7.13	1.04
Minimum	20400	2700	37800	3920	87	1190	282	5.40	0.94
Mean	59122	40832	78533	26103	971	5808	3977	6.57	1.00
Median	53900	36850	72289	21780	832	5560	3875	6.60	1.00
St. Dev.	24702	23284	22434	24512	654	2148	1926	0.30	0.02

OCEAN MONITORING DATA FOR TSS (mg/L)

September 1993 - September 1996

DATE	VOLUME DISPOSED (gallons)	STATION AND DEPTH																	
		CONTROL			STATION 1			STATION 2			STATION 3			STATION 4			STATION 5		
		1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)
10-Sep-93	310750	1.0	0.9	1.2	1.0	1.1	1.4	1.7	1.1	1.4	0.6	1.5	1.0	1.6	1.4	2.1	1.6	1.1	1.6
27-Oct-93	185000	1.2	1.0	1.9	1.6	2.4	2.2	2.6	2.4	1.4	1.6	1.3	1.2	1.6	1.6	1.8	1.2	1.0	1.0
17-Nov-93	301000	1.7	2.2	2.5	1.0	1.2	2.3	1.3	1.8	2.4	1.1	1.0	1.2	2.2	1.0	2.2	1.1	1.0	2.3
10-Dec-93	158000	6.3	18.0	8.7	7.4	14.9	8.7	9.6	9.5	8.1	7.9	8.3	8.3	9.2	7.0	9.4	6.7	9.4	6.8
21-Jan-94	259000	1.8	0.6	0.7	1.2	0.6	2.8	1.7	1.0	1.1	1.0	2.4	1.1	1.0	1.0	1.3	1.0	1.4	0.8
9-Feb-94	147000	1.4	1.4	1.8	1.1	1.6	1.8	1.0	1.5	1.0	2.0	1.5	2.2	1.8	1.8	1.2	0.8	1.0	0.7
9-Mar-94	292000	2.0	1.4	1.3	3.2	2.2	1.6	1.2	1.0	2.2	2.0	1.0	1.5	2.0	2.0	1.8	1.6	0.9	1.9
26-Apr-94	288000	1.5	1.0	2.3	1.0	1.6	1.4	1.8	1.0	1.3	0.6	0.9	0.8	0.7	1.5	0.9	0.5	0.7	1.6
23-May-94	157000	1.1	1.0	1.0	0.9	1.0	0.9	1.2	1.2	1.6	1.1	0.6		1.0	1.0	1.4	1.0	0.9	1.0
15-Jun-94	265000	1.1	1.0	1.4	1.0	3.2	2.0	1.1	1.2	1.5	1.0	1.2	0.7	0.9	0.8	2.0	1.6	1.0	0.7
21-Jul-94	259000	1.8	0.9	0.8	0.8	0.9	1.7	0.8	1.8	1.0	1.2	1.0	1.0	2.0	2.7	2.0	1.5	0.9	1.6
16-Aug-94	113300	0.4	0.8	0.8	0.8	0.9	0.7	0.9	0.7	0.5	0.6	0.6	1.0	0.4	0.4	0.7	1.4	0.6	0.4
20-Sep-94	282000	0.8	1.0	1.7	3.7	0.8	0.8	1.4	2.0	1.8	1.4	1.9	(28)	0.7	1.6	0.7	1.3	0.9	1.6
1-Oct-94	162000	1.6	0.9	0.9	1.2	1.6	1.0	1.1	2.5	1.0	1.4	1.2	1.0	0.9	1.9	2.0	1.1	1.8	0.8
17-Nov-94	268000	0.6	1.0	2.0	0.5	1.8	0.9	0.8	0.7	0.6	1.0	1.6	1.3	3.7	(121.8)	1.8	0.6	0.6	3.4
14-Dec-94	149000	1.8	0.9	0.8	1.3	1.4	1.0	0.8	1.6	0.5	1.0	1.2	0.9	3.3	0.7	0.8	0.9	0.8	1.1
27-Jan-95	284000	0.9	2.8	1.3	1.0	1.8	1.0	2.0	1.6	1.3	1.8	1.4	1.6	3.6	2.4	2.1	0.7	0.9	1.4
25-Feb-95	142000	1.2	1.2	5.4	3.6	1.8	1.6	1.0	3.5	3.6	0.8	1.0	3.2	3.4	1.0	0.8	1.0	0.9	1.0
3-Mar-95	241000	3.0	3.0	3.7	4.2	1.6	(49)	1.4	4.9	2.2	(19)	2.1	3.0	1.3	6.5	3.6	1.4	2.1	1.5
8-Apr-95	164000	2.8	2.8	2.0	1.3	1.0	1.6	1.8	2.0	0.8	2.2	1.8	3.0	14.5	1.2	2.4	2.4	1.6	2.4
3-May-95	195000	2.8	1.0	3.8	1.2	2.7	4.0	3.9	1.0	0.6	1.4	1.1	1.8	2.6	2.4	2.0	1.4	2.3	1.3
28-Jun-95	154000	0.9	1.8	1.2	2.0	1.2	1.5	1.4	1.4	1.1	1.2	0.8	1.0	1.4	1.2	1.2	0.9	1.2	1.4
7-Jul-95	244000	1.3	1.3	0.8	1.1	1.0	1.2	1.2	1.2	1.4	1.1	1.0	1.2	1.3	1.4	1.1	1.2	1.7	1.2
1-Aug-95	199000	1.0	1.6	2.8	1.6	3.0	6.4	6.2	3.4	6.8	3.8	1.0	2.8	3.2	1.6	1.0	1.4	1.8	1.2
14-Sep-95	224875	1.6	1.2	1.0	1.1	1.4	1.0	2.1	1.0	2.2	2.2	0.9	1.2	2.2	2.1	2.0	2.0	2.0	1.9
19-Oct-95	207867	1.4	1.1	3.0	1.5	4.8	1.4	4.0	3.9	6.0	4.0	5.2	3.4	3.1	4.0	5.7	3.2	1.2	3.8
15-Nov-95	175002	3.4	3.0	3.8	5.2	4.2	3.4	2.0	2.2	5.4	3.8	0.6	3.0	1.1	3.1	2.6	0.6	3.1	3.5
19-Dec-95	329500	1.0	1.0	1.4	1.1	1.2	1.4	2.2	2.2	1.6	1.0	1.0	0.9	1.4	1.2	1.0	0.8	0.9	0.8
15-Jan-96	154500	0.7	0.8	1.2	1.6	3.4	2.0	1.2	1.2	1.2	0.8	1.0	1.0	1.0	2.6	2.1	1.0	1.1	1.8
7-Feb-96	305875	1.6	1.2	2.1	1.6	1.2	1.3	1.2	0.8	1.2	0.8	0.8	2.0	1.4	1.2	1.0	0.8	1.9	0.8
13-Mar-96	310375	2.0	0.8	2.0	1.0	1.0	1.1	1.4	1.2	2.1	1.8	0.9	1.0	1.1	1.5	1.0	1.1	2.0	1.4
23-Apr-96	261375	1.4	2.4	1.3	1.8	2.2	1.2	1.6	2.2	2.0	1.8	1.5	1.2	1.6	1.6	1.4	1.4	1.7	1.2
2-May-96	278750	0.6	0.8	0.9	2.0	1.0	0.8	0.6	0.5	0.7	1.2	0.4	0.6	0.6	1.3	0.6	0.8	0.8	1.4
19-Jun-96	114725	1.4	2.2	1.8	1.0	1.6	1.6	1.0	1.6	2.0	1.6	1.2	1.5	2.2	1.1	1.0	1.8	2.2	2.6
10-Jul-96	163325	0.8	0.6	0.6	0.6	0.7	1.2	0.6	0.8	0.8	0.6	0.7	1.8	1.4	1.0	0.6	0.6	0.8	1.5
7-Aug-96	180100	1.0	2.2	1.8	1.7	1.6	1.8	2.2	1.8	1.0	1.0	1.2	3.6	1.7	1.2	1.0	2.4	1.6	3.1
5-Sep-96	325325	1.4	0.8	1.8	4.3	1.0	2.8	1.2	1.5	1.0	0.8	0.8	1.0	1.1	1.0	1.0	3.5	1.4	1.8

OCEAN MONITORING DATA FOR TVSS (mg/L)

September 1993 - September 1996

DATE	VOLUME DISPOSED (gallons)	STATION AND DEPTH																	
		CONTROL			STATION 1			STATION 2			STATION 3			STATION 4			STATION 5		
		1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)
10-Sep-93	310750	0.4	0.2	0.3	0.2	0.6	0.4	0.5	0.2	0.4	0.2	0.3	0.2	0.3	0.6	0.4	0.4	0.3	0.4
27-Oct-93	185000	0.4	0.2	0.6	0.9	0.1	1.0	1.2	0.8	0.6	0.9	0.5	0.7	0.5	0.4	0.6	0.2	0.4	0.2
17-Nov-93	301000	0.3	0.8	1.4	0.4	0.4	1.1	0.4	0.7	0.6	0.5	0.3	0.6	0.8	0.4	0.6	0.4	0.3	0.8
10-Dec-93	158000	0.7	(5.2)	1.2	1.3	2.4	1.5	1.7	1.9	1.3	1.3	1.4	1.2	1.9	1.3	1.5	1.4	0.9	1.3
21-Jan-94	259000	0.3	0.1	0.1	0.4	0.3	1.0	0.6	0.2	0.4	0.3	0.4	0.2	0.4	0.3	0.4	0.1	0.4	0.2
9-Feb-94	147000	0.5	0.6	0.4	0.6	0.8	1.3	0.6	0.6	0.5	0.5	0.6	0.7	0.6	0.6	0.4	0.2	0.4	0.6
9-Mar-94	292000	0.6	0.4	0.4	1.1	1.5	0.6	0.6	0.6	0.9	0.6	0.6	1.1	0.5	0.8	0.5	0.4	0.2	0.6
26-Apr-94	288000	0.4	0.4	1.0	0.4	0.5	0.6	0.4	0.4	0.6	0.3	0.4	0.4	0.3	0.4	0.3	0.3	0.2	0.4
23-May-94	157000	0.4	0.4	0.4	0.3	0.2	0.4	0.4	0.6	0.6	0.4	0.4		0.2	0.6	0.6	0.2	0.4	0.4
15-Jun-94	265000	0.2	0.2	1.0	0.4	1.7	1.9	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.1	0.4	0.8	0.8	0.2
21-Jul-94	259000	0.9	0.4	0.2	0.3	0.4	0.8	0.4	0.6	0.3	0.4	0.4	0.5	0.6	1.2	0.6	0.4	0.4	0.4
16-Aug-94	113300	0.2	0.2	0.2	0.4	0.2	0.3	0.4	0.2	0.2	0.2	0.1	0.3	0.2	0.1	0.2	0.4	0.2	0.2
20-Sep-94	282000	0.3	0.5	0.4	0.7	0.2	0.3	0.7	1.0	1.4	0.8	0.6	(23.9)	0.2	0.2	0.2	0.4	0.4	0.1
1-Oct-94	162000	0.4	0.2	0.2	0.2	0.4	0.2	0.3	0.4	0.2	0.2	0.3	0.2	0.1	0.4	0.4	0.2	0.3	0.3
17-Nov-94	268000	0.1	0.4	0.6	0.1	0.6	0.5	0.3	0.2	0.2	0.2	0.4	0.2	2.7	(102.2)	0.6	0.2	0.2	2.5
14-Dec-94	149000	1.0	0.4	0.8	0.7	1.2	0.6	0.6	1.2	0.3	0.6	0.8	0.8	1.0	0.4	0.6	0.6	0.4	0.8
27-Jan-95	284000	**0.1**	0.4	0.2	0.3	0.6	0.1	0.9	0.6	0.7	0.8	0.6	0.4	1.4	1.0	0.8	**0.1**	0.3	0.4
25-Feb-95	142000	0.5	0.4	1.8	1.2	0.9	1.0	0.6	1.0	1.4	0.5	0.8	0.9	0.9	0.5	0.5	0.3	0.4	0.3
3-Mar-95	241000	0.9	0.8	0.8	1.1	0.4	(13.0)	0.4	1.2	0.9	(4.2)	0.6	1.8	0.6	2.6	1.0	0.6	0.8	0.6
8-Apr-95	164000	1.1	1.3	1.0	0.5	0.4	0.8	0.8	0.6	0.4	0.8	0.9	0.4	(10.6)	0.6	0.6	1.4	0.6	0.6
3-May-95	195000	1.4	0.7	2.9	0.8	0.9	1.2	3.5	0.4	0.6	0.4	0.4	0.5	1.0	0.6	0.5	0.7	1.2	0.8
28-Jun-95	154000	0.4	0.4	0.3	0.8	0.5	0.6	0.4	0.4	0.6	0.4	0.4	0.2	0.7	0.4	0.4	0.4	0.6	0.5
7-Jul-95	244000	0.4	0.4	0.3	0.4	0.2	0.4	0.3	0.2	0.4	0.4	0.4	0.3	0.3	0.4	0.4	0.4	0.4	0.4
1-Aug-95	199000	0.5	0.4	0.6	0.6	0.6	1.4	1.5	0.6	1.6	0.8	0.3	0.8	1.0	0.2	0.2	0.3	0.6	0.3
14-Sep-95	224875	1.0	0.5	0.4	0.4	0.4	0.2	0.5	0.4	0.6	0.6	0.4	0.6	0.4	0.4	0.6	0.4	0.6	0.7
19-Oct-95	207867	0.6	0.4	1.0	0.6	1.3	0.6	1.0	1.1	1.3	1.0	1.1	1.0	0.7	1.0	1.2	0.8	0.4	1.0
15-Nov-95	175002	0.6	0.6	0.8	1.2	0.8	0.7	0.6	0.8	1.4	0.7	0.1	0.5	0.3	0.5	0.3	0.2	0.6	0.6
19-Dec-95	329500									0.8									
15-Jan-96	154500	0.3	0.2	0.6	1.0	1.2	1.0	0.6	0.6	0.5	0.4	0.5	0.6	0.6	0.8	0.6	0.4	0.4	0.6
7-Feb-96	305875	0.4	0.4	0.6	0.3	0.4	0.4	0.3	0.3	0.3	0.2	**0.1**	0.4	0.6	0.6	0.4	0.2	0.4	0.2
13-Mar-96	310375	0.4	0.1	0.8	0.2	0.2	0.3	0.4	0.4	0.6	0.4	0.2	0.2	0.2	0.4	0.3	0.2	0.6	0.4
23-Apr-96	261375	0.4	0.7	0.3	0.4	0.6	0.4	0.5	0.6	0.5	0.6	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4
2-May-96	278750	0.3	0.2	0.3	1.2	0.5	0.3	0.2	0.2	0.2	0.2	**0.1**	0.2	0.2	0.2	0.2	0.2	0.2	0.3
19-Jun-96	114725	0.6	0.7	0.8	0.4	0.5	0.5	0.5	0.5	0.6	0.4	0.6	0.6	0.6	0.3	0.3	0.5	0.6	1.0
10-Jul-96	163325	0.3	0.3	0.4	0.2	0.4	0.3	0.4	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.2	0.3	0.4	0.4
7-Aug-96	180100	0.4	0.4	0.4	0.6	0.8	0.8	0.8	0.7	0.4	0.2	0.6	1.1	1.0	0.4	0.4	0.8	0.7	0.7
5-Sep-96	325325	0.6	0.4	0.7	1.2	0.3	0.7	0.2	0.4	0.2	0.1	0.3	0.3	0.5	0.4	0.4	0.7	0.4	0.4

OCEAN MONITORING DATA FOR O&G (mg/L)

September 1993 - September 1996

DATE	VOLUME DISPOSED (gallons)	STATION AND DEPTH																	
		CONTROL			STATION 1			STATION 2			STATION 3			STATION 4			STATION 5		
		1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)
10-Sep-93	310750	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
27-Oct-93	185000	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
17-Nov-93	301000	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
10-Dec-93	158000	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
21-Jan-94	259000	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
9-Feb-94	147000	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
9-Mar-94	292000	0.61	0.61	0.61	0.90	1.60	0.80	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
26-Apr-94	288000	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
23-May-94	157000	0.61	0.61	0.61	0.61	0.61		0.61	0.61	0.61	0.61	0.61	0.61		0.61	0.61	0.61	0.61	0.61
15-Jun-94	265000	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
21-Jul-94	259000	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
16-Aug-94	113300	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
20-Sep-94	282000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.50	1.00	1.00	(12.40)	1.00	1.00	1.00	1.00	1.00	1.00
1-Oct-94	162000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
17-Nov-94	268000	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	(40.00)	(31.60)	3.20	0.61	0.61	0.61
14-Dec-94	149000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
27-Jan-95	284000	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
25-Feb-95	142000	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
3-Mar-95	241000	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
8-Apr-95	164000	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	(47.60)	0.61	0.61	0.61	0.61	0.61
3-May-95	195000	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
28-Jun-95	154000	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	1.08	0.61	0.61
7-Jul-95	244000	0.78	0.61	1.12	0.61	0.61	1.28	1.28	0.78	1.79	0.61	0.61	0.61	0.61	0.61	0.61	0.95	0.61	0.61
1-Aug-95	199000	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
14-Sep-95	224875	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
19-Oct-95	207867	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
15-Nov-95	175002	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
19-Dec-95	329500	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
15-Jan-96	154500	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
7-Feb-96	305875	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
13-Mar-96	310375	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
23-Apr-96	261375	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
2-May-96	278750	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
19-Jun-96	114725	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
10-Jul-96	163325	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
7-Aug-96	180100	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
5-Sep-96	325325	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61

OCEAN MONITORING DATA FOR Total Phosphorous (mg-P/L)

September 1993 - September 1996

DATE	VOLUME DISPOSED (gallons)	STATION AND DEPTH																	
		CONTROL			STATION 1			STATION 2			STATION 3			STATION 4			STATION 5		
		1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)
10-Sep-93	310750	0.012	0.025	0.049	0.132	0.049	0.058	0.017	0.015	0.025	0.017	0.057	0.041	0.049	0.243	0.058	0.074	0.054	0.066
27-Oct-93	185000	0.014	0.016	0.016	0.026	0.017	0.033	0.115	0.240	0.052	0.039	0.016	0.026	0.028	0.023	0.026	0.014	0.015	0.016
17-Nov-93	301000	0.010	0.012	0.013	0.019	0.013	0.027	0.048	0.032	0.022	0.029	0.019	0.014	0.026	0.023	0.029	0.034	0.025	0.017
10-Dec-93	158000	0.034	0.022	0.093	0.025	0.036	0.063	0.022	0.084	0.062	0.038	0.034	0.065	0.031	0.083	0.042	0.046	0.038	0.024
21-Jan-94	259000	0.024	0.024	0.014	0.014	0.057	0.031	0.017	0.006	0.005	0.009	0.010	0.012	0.012	0.006	0.006	0.006	0.007	0.006
9-Feb-94	147000	0.032	0.028	0.032	0.042	0.044	0.061	0.047	0.047	0.048	0.061	0.038	0.049	0.045	0.030	0.030	0.030	0.038	0.045
9-Mar-94	292000	0.009	0.015	0.008	0.028	0.024	0.022	0.012	0.023	0.014	0.016	0.015	0.030	0.024	0.024	0.028	0.015	0.017	0.018
26-Apr-94	288000	0.058	0.114	0.045	0.021	0.018	0.028	0.023	0.027	0.021	0.018	0.018	0.015	0.015	0.020	0.020	0.015	0.015	0.024
23-May-94	157000	0.027	0.027	0.022	0.016	0.023	0.046	0.037	0.046	0.031	0.019	0.019	0.037	0.019	0.019	0.023	0.028	0.025	0.020
15-Jun-94	265000	0.037	0.067	0.026	0.045	0.030	0.036	0.037	0.178	0.080	0.039	0.037	0.025	0.027	0.029	0.038	0.031	0.031	0.015
21-Jul-94	259000	0.021	0.016	0.024	0.024	0.021	0.029	0.019	0.019	0.017	0.017	0.023	0.019	0.027	0.025	0.043	0.011	0.012	0.012
16-Aug-94	113300	0.025	0.022	0.027	0.026	0.023	0.053	0.044	0.038	0.032	0.041	0.032	0.034	0.026	0.052	0.115	0.048	0.059	0.057
20-Sep-94	282000	0.031	0.027	0.032	0.040	0.035	0.032	0.051	0.047	0.075	0.078	0.035	0.213	0.029	0.032	0.033	0.058	0.038	0.033
1-Oct-94	162000	0.014	0.015	0.035	0.026	0.029	0.033	0.022	0.023	0.019	0.031	0.017	0.015	0.014	0.018	0.025	0.016	0.016	0.016
17-Nov-94	268000	0.520	0.019	0.021	0.031	0.026	0.023	0.024	0.023	0.019	0.018	0.020	0.018	0.390	0.021	0.020	0.120	0.016	0.019
14-Dec-94	149000	0.023	0.026	0.017	0.038	0.044	0.035	0.018	0.015	0.571	0.018	0.015	0.016	0.020	0.021	0.023	0.019	0.018	0.017
27-Jan-95	284000	0.013	0.030	0.024	0.039	0.023	0.024	0.035	0.097	0.032	0.032	0.028	0.032	0.039	0.047	0.040	0.042	0.032	0.026
25-Feb-95	142000	0.014	0.018	0.016	0.036	0.034	0.034	0.022	0.021	0.020	0.016	0.018	0.019	0.015	0.015	0.022	0.197	0.018	0.015
3-Mar-95	241000	0.050	0.021	0.018	0.019	0.044	0.039	0.031	0.029	0.050	0.024	0.026	0.028	0.033	0.030	0.024	0.047	0.031	0.030
8-Apr-95	164000	0.030	0.017	0.021	0.029	0.024	0.032	0.024	0.016	0.014	0.027	0.029	0.027	0.025	0.040		0.019	0.022	0.027
3-May-95	195000	0.050	0.021	0.018	0.019	0.044	0.039	0.031	0.029	0.050	0.024	0.026	0.028	0.033	0.030	0.024	0.047	0.031	0.030
28-Jun-95	154000	0.063	0.047	0.076	0.067	0.077	0.056	0.072	0.053	0.045	0.048	0.056	0.050	0.307	0.053	0.056	0.065	0.053	0.049
7-Jul-95	244000	0.045	0.041	0.053	0.045	0.034	0.037	0.051	0.028	0.065	0.042	0.037	0.034	0.040	0.047	0.036	0.046	0.038	0.039
1-Aug-95	199000	0.020	0.022	0.026	0.025	0.034	0.020	0.028	0.025	0.021	0.061	0.024	0.022	0.017	0.019	0.019	0.019	0.024	0.022
14-Sep-95	224875	0.172	0.021	0.021	0.015	0.014	0.017	0.015	0.014	0.013	0.015	0.015	0.016	0.018	0.017	0.020	0.021	0.015	0.015
19-Oct-95	207867	0.044	0.043	0.038	0.029	0.037	0.038	0.034	0.040	0.038	0.046	0.024	0.037	0.152	0.034	0.041	0.027	0.034	0.037
15-Nov-95	175002	0.018	0.019	0.018	0.023	0.026	0.026	0.026	0.034	0.043	0.020	0.018	0.022	0.020	0.017	0.017	0.016	0.037	0.025
19-Dec-95	329500	0.027	0.026	0.030	0.030	0.033	0.028	0.105	0.079	0.052	0.037	0.034	0.029	0.041	0.045	0.049	0.018	0.023	0.017
15-Jan-96	154500	0.204	0.052	0.072	0.065	0.069	0.096	0.045	0.077	0.070	0.061	0.048	0.057	0.057	0.090	0.086	0.239	0.055	0.079
7-Feb-96	305875	0.044	0.047	0.050	0.048	0.026	0.043	0.034	0.036	0.035	0.029	0.028	0.035	0.055	0.123	0.045	0.090	0.027	0.032
13-Mar-96	310375	0.019	0.020	0.023	0.018	0.017	0.016	0.044	0.027	0.030	0.025	0.024	0.023	0.017	0.039	0.024	0.026	0.031	0.034
23-Apr-96	261375	0.020	0.017	0.025	0.014	0.021	0.023	0.029	0.027	0.038	0.039	0.040	0.041	0.125	0.025	0.025	0.024	0.026	0.026
2-May-96	278750	0.041	0.029	0.034	0.042	0.031	0.025	0.014	0.016	0.016	0.013	0.015	0.015	0.026	0.024	0.013	0.015	0.017	0.017
19-Jun-96	114725	0.030	0.032	0.035	0.035	0.571	0.036	0.023	0.033	0.034	0.035	0.034	0.038	0.035	0.034	0.030	0.037	0.031	0.038
10-Jul-96	163325	0.148	0.022	0.017	0.015	0.017	0.009	0.014	0.012	0.015	0.013	0.005	0.016	0.016	0.016	0.016	0.017	0.016	0.017
7-Aug-96	180100	0.038	0.038	0.047	0.239	0.029	0.046	0.041	0.047	0.044	0.040	0.043	0.042	0.041	0.040	0.047	0.043	0.037	0.036
5-Sep-96	325325	0.032	0.024	0.040	0.040	0.050	0.066	0.125	0.038	0.034	0.022	0.018	0.020	0.040	0.038	0.037	0.021	0.023	0.024

OCEAN MONITORING DATA FOR TOTAL NITROGEN (mg-N/L)

September 1993 - September 1996

DATE	VOLUME DISPOSED (gallons)	STATION AND DEPTH																	
		CONTROL			STATION 1			STATION 2			STATION 3			STATION 4			STATION 5		
		1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)
10-Sep-93	310750	0.133	0.106	0.114	0.597	0.170	0.352	0.121	0.150	0.187	0.176	0.148	0.152	0.152	0.174	0.154	0.151	0.202	0.223
27-Oct-93	185000	0.222	0.184	0.206	0.463	0.372	0.471	0.480	0.434	0.383	0.272	0.304	0.371	0.266	0.336	0.270	0.174	0.189	0.273
17-Nov-93	301000	0.033	0.116	0.132	0.160	0.159	0.158	0.148	0.156	0.175	0.135	0.177	0.157	0.126	0.191	0.190	0.103	0.102	0.105
10-Dec-93	158000	0.239	0.126	0.771	0.232	0.202	0.239	0.146	0.190	0.235	0.189	0.184	0.227	0.248	0.392	0.197	0.145	0.197	0.166
21-Jan-94	259000	0.168	0.161	0.179	0.350	0.330	0.406	0.348	0.220	0.357	0.204	0.198	0.185	0.273	0.235	0.212	0.128	0.120	0.118
9-Feb-94	147000	0.115	0.161	0.215	0.465	0.618	0.712	0.491	0.612	0.473	0.190	0.478	0.970	0.368	0.267	0.270	0.178	0.215	0.199
9-Mar-94	292000	0.120	0.194	0.165	0.308	0.344	0.388	0.195	0.178	0.228	0.228	0.165	0.292	0.253	0.240	0.308	0.247	0.247	0.198
26-Apr-94	288000	0.081	0.356	0.214	0.211	0.226	0.342	0.282	0.218	0.213	0.182	0.210	0.165	0.148	0.217	0.199	0.145	0.198	0.193
23-May-94	157000	0.210	0.215	0.202	0.150	0.187	0.565	0.260	0.272	0.488	0.208	0.191	0.241	0.173	0.640	0.164	0.136	0.118	0.363
15-Jun-94	265000	0.126	0.158	0.142	0.258	0.252	0.241	0.252	0.320	0.318	0.248	0.238	0.244	0.126	0.133	0.169	0.117	0.138	0.102
21-Jul-94	259000	0.252	0.135	0.122	0.169	0.148	0.418	0.164	0.200	0.147	0.180	0.518	0.161	0.268	0.213	0.418	0.112	0.155	0.130
16-Aug-94	113300	0.133	0.150	0.160	0.176	0.177	0.210	0.245	0.203	0.154	0.328	0.168	0.181	0.151	0.172	0.155	0.156	0.139	0.135
20-Sep-94	282000	0.249	0.210	0.208	0.249	0.198	0.158	0.312	0.522	0.659	0.492	0.243	0.713	0.103	0.157	0.121	0.203	0.201	0.205
1-Oct-94	162000	0.266	0.173	0.344	0.298	0.318	0.345	0.212	0.253	0.231	0.222	0.210	0.164	0.140	0.172	0.232	0.164	0.189	0.182
17-Nov-94	268000	(2.180)	0.309	0.181	0.248	0.278	0.237	0.175	0.165	0.110	0.181	0.191	0.146	0.860	0.120	0.189	0.130	0.150	0.130
14-Dec-94	149000	0.294	0.196	0.142	0.409	0.505	0.362	0.211	0.152	0.236	0.175	0.180	0.208	0.248	0.121	0.137	0.118	0.149	0.129
27-Jan-95	284000	0.135	0.168	0.132	0.281	0.202	0.249	0.362	0.346	0.248	0.299	0.270	0.286	0.260	0.267	0.326	0.197	0.214	0.171
25-Feb-95	142000	0.136	0.145	0.262	0.292	0.407	0.312	0.181	0.168	0.158	0.156	0.427	0.618	0.219	0.252	0.177	0.945	0.130	0.132
3-Mar-95	241000	0.159	0.222	0.195	0.785	0.591	0.280	0.155	0.226	0.561	0.298	0.240	0.355	0.432	0.235	0.248	0.400	0.293	0.236
8-Apr-95	164000	0.303	0.184	0.153	0.668	0.193	0.338	0.220	0.145	0.140	0.268	0.268	0.274	0.448	0.185		0.220	0.176	0.274
3-May-95	195000	0.124	0.134	0.668	0.262	0.318	0.330	0.399	0.157	0.127	0.157	0.173	0.262	0.195	0.167	0.141	0.484	0.345	0.422
28-Jun-95	154000	0.568	0.322	0.433	0.212	0.232	0.240	0.246	0.175	0.166	0.427	0.171	0.211	0.355	0.191	0.206	0.254	0.282	0.154
7-Jul-95	244000	0.215	0.143	0.245	0.154	0.130	0.098	0.166	0.125	0.140	0.188	0.088	0.261	0.144	0.168	0.170	0.163	0.123	0.119
1-Aug-95	199000	0.118	0.106	0.090	0.120	0.201	0.125	0.121	0.107	0.076	0.106	0.108	0.116	0.105	0.111	0.099	0.090	0.127	0.111
14-Sep-95	224875	0.175	0.144	0.155	0.160	0.142	0.128	0.112	0.107	0.136	0.144	0.118	0.130	0.102	0.105	0.152	0.122	0.106	0.115
19-Oct-95	207867	0.218	0.151	0.187	0.240	0.230	0.094	0.128	0.332	0.181	0.138	0.136	0.171	0.234	0.140	0.136	0.148	0.160	0.136
15-Nov-95	175002	0.152	0.144	0.211	0.280	0.262	0.221	0.280	0.217	0.384	0.114	0.103	0.160	0.269	0.159	0.191	0.133	0.180	0.195
19-Dec-95	329500	0.149	0.175	0.236	0.196	0.222	0.237	0.590	0.399	0.342	0.146	0.142	0.168	0.242	0.302	0.396	0.122	0.107	0.122
15-Jan-96	154500	0.104	0.122	0.680	0.124	0.213	0.183	0.148	0.255	0.183	0.088	0.153	0.126	0.158	0.228	0.143	0.149	0.114	0.264
7-Feb-96	305875	0.109	0.125	0.139	0.129	0.097	0.144	0.132	0.161	0.125	0.098	0.092	0.120	0.241	0.319	0.203	0.156	0.134	0.139
13-Mar-96	310375	0.116	0.109	0.140	0.126	0.127	0.133	0.168	0.115	0.183	0.142	0.161	0.152	0.123	0.118	0.113	0.119	0.111	0.116
23-Apr-96	261375	0.176	0.142	0.151	0.171	0.144	0.238	0.168	0.201	0.244	0.226	0.221	0.246	0.183	0.179	0.141	0.127	0.215	0.150
2-May-96	278750	0.124	0.118	0.153	0.264	0.149	0.180	0.106	0.106	0.111	0.105	0.142	0.116	0.102	0.110	0.098	0.100	0.102	0.124
19-Jun-96	114725	0.242	0.178	0.218	0.227	0.206	0.223	0.145	0.146	0.188	0.124	0.122	0.245	0.145	0.128	0.129	0.168	0.146	0.207
10-Jul-96	163325	0.125	0.137	0.151	0.116	0.110	0.164	0.163	0.146	0.156	0.138	0.160	0.115	0.117	0.123	0.114	0.135	0.137	0.119
7-Aug-96	180100	0.168	0.332	0.192	0.166	0.190	0.308	0.193	0.208	0.197	0.168	0.182	0.183	0.154	0.184	0.159	0.121	0.136	0.215
5-Sep-96	325325	0.134	0.116	0.199	0.187	0.226	0.136	0.159	0.131	0.139	0.128	0.129	0.159	0.138	0.162	0.207	0.161	0.147	0.148

OCEAN MONITORING DATA FOR AMMONIA (mg-N/L)

September 1993 - September 1996

DATE	VOLUME DISPOSED (gallons)	STATION AND DEPTH																	
		CONTROL			STATION 1			STATION 2			STATION 3			STATION 4			STATION 5		
		1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)	1 (m)	3 (m)	10 (m)
10-Sep-93	310750	0.010	0.012	0.014	0.089	0.043	0.080	0.019	0.065	0.084	0.082	0.079	0.068	0.042	0.077	0.083	0.067	0.105	0.109
27-Oct-93	185000	0.016	0.016	0.018	0.146	0.131	0.156	0.143	0.132	0.093	0.075	0.065	0.121	0.075	0.085	0.073	0.027	0.024	0.032
17-Nov-93	301000	0.013	0.013	0.033	0.032	0.045	0.075	0.034	0.063	0.083	0.048	0.079	0.062	0.030	0.065	0.083	0.026	0.018	0.023
10-Dec-93	158000	0.082	0.019	0.199	0.073	0.053	0.084	0.022	0.031	0.023	0.032	0.044	0.042	0.045	0.059	0.037	0.044	0.032	0.027
21-Jan-94	259000	0.005	0.008	0.014	0.060	0.041	0.061	0.031	0.026	0.037	0.048	0.037	0.032	0.052	0.051	0.035	0.010	0.012	0.010
9-Feb-94	147000	0.001	0.007	0.008	0.048	0.112	0.134	0.073	0.069	0.040	0.014	0.060	0.038	0.047	0.021	0.034	0.005	0.008	0.008
9-Mar-94	292000	0.012	0.033	0.022	0.125	0.123	0.123	0.035	0.040	0.064	0.070	0.045	0.084	0.118	0.117	0.141	0.069	0.057	0.053
26-Apr-94	288000	0.026	0.039	0.031	0.042	0.048	0.039	0.064	0.064	0.040	0.040	0.032	0.020	0.030	0.052	0.042	0.023	0.026	0.045
23-May-94	157000	0.031	0.021	0.010	0.008	0.011	0.030	0.057	0.042	0.064	0.030	0.028	0.047	0.028	0.075	0.034	0.018	0.007	0.053
15-Jun-94	265000	0.008	0.026	0.006	0.072	0.060	0.074	0.066	0.113	0.110	0.045	0.052	0.068	0.038	0.026	0.033	0.007	0.013	0.012
21-Jul-94	259000	0.024	0.007	0.008	0.012	0.008	0.034	0.015	0.012	0.006	0.025	0.050	0.013	0.076	0.076	0.202	0.010	0.017	0.029
16-Aug-94	113300	0.012	0.008	0.020	0.013	0.028	0.040	0.047	0.062	0.030	0.079	0.040	0.065	0.011	0.015	0.011	0.011	0.010	0.011
20-Sep-94	282000	0.015	0.007	0.016	0.053	0.039	0.027	0.142	0.097	(0.248)	0.091	0.069	0.140	0.008	0.006	0.012	0.017	0.009	0.010
1-Oct-94	162000	0.019	0.017	0.025	0.055	0.063	0.074	0.060	0.049	0.067	0.035	0.038	0.013	0.011	0.032	0.059	0.020	0.016	0.025
17-Nov-94	268000	0.250	0.008	**0.001**	0.021	0.035	0.022	0.034	0.032	0.014	0.010	0.030	0.026	0.026	0.020	0.022	0.005	0.003	0.004
14-Dec-94	149000	0.030	0.011	0.004	0.147	0.182	0.112	0.022	0.009	0.022	0.013	0.008	0.008	0.023	0.006	0.010	0.005	0.011	0.009
27-Jan-95	284000	0.008	0.007	0.009	0.075	0.026	0.047	0.124	0.116	0.077	0.119	0.096	0.090	0.090	0.113	0.139	0.033	0.021	0.018
25-Feb-95	142000	0.007	0.009	0.029	0.132	0.179	0.164	0.062	0.049	0.049	0.020	0.029	0.068	0.019	0.019	0.013	(0.524)	0.009	0.009
3-Mar-95	241000	0.020	0.014	0.020	0.142	0.095	0.058	0.017	0.023	0.084	0.062	0.053	0.062	0.105	0.063	0.066	0.086	0.084	0.058
8-Apr-95	164000	0.128	0.093	0.083	(0.224)	0.155	(0.247)	0.191	0.125	0.111	0.134	0.139	0.114	0.078	0.046		0.036	0.047	0.058
3-May-95	195000	0.008	0.010	(0.241)	0.016	0.038	0.032	0.013	0.011	0.015	0.016	0.012	0.045	0.011	0.011	0.012	0.260	(0.242)	0.197
28-Jun-95	154000	0.026	0.017	0.020	0.018	0.020	0.018	0.015	0.004	0.001	0.044	0.008	0.006	0.013	0.003	0.004	0.037	0.014	0.004
7-Jul-95	244000	0.016	0.013	0.018	0.011	0.014	0.007	0.015	0.010	0.021	0.019	0.048	0.023	0.019	0.026	0.014	0.023	0.022	0.020
1-Aug-95	199000	0.010	0.019	0.010	0.047	0.082	0.022	0.013	0.019	0.008	0.009	0.021	0.011	0.012	0.009	0.009	0.014	0.016	0.011
14-Sep-95	224875	0.017	0.005	0.006	0.006	0.005	0.005	0.003	0.006	0.005	0.005	0.006	0.004	0.007	0.004	0.010	0.008	0.009	0.006
19-Oct-95	207867	0.013	0.008	0.012	0.028	0.016	0.005	0.013	0.033	0.004	0.010	0.020	0.031	0.009	0.004	0.005	0.002	0.006	0.006
15-Nov-95	175002	0.017	0.014	0.029	0.079	0.074	0.054	0.102	0.073	0.127	0.011	0.009	0.019	0.037	0.017	0.028	0.015	0.018	0.025
19-Dec-95	329500	0.013	0.015	0.021	0.028	0.067	0.057	(0.351)	(0.253)	0.111	0.027	0.023	0.027	0.102	0.135	0.189	0.010	0.009	0.009
15-Jan-96	154500	0.008	0.008	0.103	0.023	0.029	0.030	0.023	0.031	0.032	0.006	0.018	0.009	0.010	0.013	0.004	0.004	0.005	0.014
7-Feb-96	305875	0.006	0.003	0.003	0.005	0.004	0.008	0.006	0.008	0.007	0.004	0.005	0.007	0.061	0.056	0.035	0.015	0.007	0.112
13-Mar-96	310375	0.005	0.005	0.005	0.007	0.008	0.009	0.019	0.007	0.060	0.023	0.039	0.037	0.006	0.007	0.007	0.019	0.006	0.005
23-Apr-96	261375	0.024	0.012	0.013	0.018	0.012	0.025	0.042	0.040	0.053	0.088	0.049	0.068	0.034	0.033	0.029	0.012	0.025	0.012
2-May-96	278750	0.010	0.006	0.005	0.119	0.038	0.034	0.003	0.003	0.004	0.005	0.011	0.006	0.006	0.007	0.003	0.004	0.004	0.006
19-Jun-96	114725	0.011	0.012	0.012	0.038	0.016	0.026	0.010	0.007	0.015	0.007	0.008	0.016	0.009	0.007	0.006	0.022	0.009	0.017
10-Jul-96	163325	0.016	0.010	0.008	0.007	0.006	0.021	0.048	0.028	0.036	0.016	0.013	0.010	0.006	0.007	0.006	0.009	0.006	0.007
7-Aug-96	180100	0.025	0.022	0.012	0.030	0.035	0.030	0.024	0.059	0.057	0.021	0.062	0.056	0.038	0.044	0.035	0.012	0.008	0.025
5-Sep-96	325325	0.007	0.007	0.010	0.009	0.013	0.013	0.015	0.007	0.005	0.006	0.005	0.005	0.005	0.006	0.011	0.006	0.005	0.004

Calculation of Dilution Using Available Field Data and Discharge Characteristics

	TP (mg-P/l)			TN (mg-N/l)			Ammonia (mg-N/l)		
Samoa Packing High Strength Waste Concetration	1200			6160			2430		
StarKist Samoa High Strength Waste Concetration	832			5560			3875		
Combined Median Concentration of High Strength Waste	1008			5848			3181		
Depth	**1 m**	**3 m**	**10 m**	**1 m**	**3 m**	**10 m**	**1 m**	**3 m**	**10 m**
Median Concentrations at:									
Background (Station 1C)	0.03	0.024	0.026	0.1505	0.151	0.187	0.013	0.012	0.0135
Station 1 @ 0.0 nmiles	0.029	0.03	0.033	0.232	0.206	0.239	0.035	0.038	0.034
Station 2 @ 0.25 nmiles	0.031	0.029	0.034	0.181	0.19	0.187	0.0275	0.0325	0.0385
Station 3 @ 0.5 nmiles	0.029	0.024	0.028	0.18	0.177	0.183	0.025	0.037	0.032
Station 4 @ 1.0 nmiles	0.028	0.03	0.0285	0.183	0.179	0.1735	0.028	0.026	0.0285
Station 5 - Farfield	0.028	0.026	0.024	0.148	0.149	0.15	0.015	0.0115	0.014
Calculated Dilutions at:									
Station 1 @ 0.0 nmiles	N/C	168,059	144,051	71,753	106,325	112,458	144,609	122,361	155,190
Station 2 @ 0.25 nmiles	N/C	201,671	126,044	191,733	149,945	N/C	219,406	155,190	127,255
Station 3 @ 0.5 nmiles	N/C	N/C	504,177	198,232	224,917	N/C	265,116	127,256	171,967
Station 4 @ 1.0 nmiles	N/C	168,059	403,342	179,934	208,852	N/C	212,092	227,242	212,092
Station 5 - Farfield	N/C	504,178	N/C	N/C	N/C	N/C	1,590,694	N/C	6,362,773

Calculation of Dilution Using Available Field Data and Discharge Characteristics

	TSS (mg/l)			TVSS (mg/l)			O&G (mg/l)		
Samoa Packing High Strength Waste Concetration	16800			8770			14780		
StarKist Samoa High Strength Waste Concetration	53900			36850			21780		
Combined Median Concentration of High Strength Waste	36092			23372			18420		
Depth	**1 m**	**3 m**	**10 m**	**1 m**	**3 m**	**10 m**	**1 m**	**3 m**	**10 m**
Median Concentrations at:									
Background (Station 1C)	1.4	1	1.7	0.4	0.4	0.6	0.61	0.61	0.61
Station 1 @ 0.0 nmiles	1.2	1.6	1.45	0.45	0.5	0.6	0.61	0.61	0.61
Station 2 @ 0.25 nmiles	1.4	1.5	1.4	0.5	0.6	0.6	0.61	0.61	0.61
Station 3 @ 0.5 nmiles	1.2	1	1.2	0.4	0.4	0.45	0.61	0.61	0.61
Station 4 @ 1.0 nmiles	1.6	1.45	1.4	0.5	0.4	0.4	0.61	0.61	0.61
Station 5 - Farfield	1.2	1.1	1.4	0.4	0.4	0.4	0.61	0.61	0.61
Calculated Dilutions at:									
Station 1 @ 0.0 nmiles	N/C	60,152	N/C	467,424	233,712	N/C	N/C	N/C	N/C
Station 2 @ 0.25 nmiles	N/C	72,182	N/C	233,712	116,856	N/C	N/C	N/C	N/C
Station 3 @ 0.5 nmiles	N/C	N/C	N/C	N/C	N/C	N/C	N/C	N/C	N/C
Station 4 @ 1.0 nmiles	180,453	80,202	N/C	233,712	N/C	N/C	N/C	N/C	N/C
Station 5 - Farfield	N/C	360,910	N/C	N/C	N/C	N/C	N/C	N/C	N/C

Calculation of Distance Between Station 4 and Station 5 for Ocean Monitoring Sampling

Distance Corresponding to 1 min of Latitude = *1.01* *nmile/min*
Distance Corresponding to 1 min of Longitude = *0.98* *nmile/min*

Date	Station 4		Station 5		Difference		Distance between
	Lat 14°S+min.	Long 170°W+min	Lat 14°S+min.	Long 170°W+min	Lat minutes	Long minutes	Stations 4 & 5 nmiles
28-Jun-95	24.32	38.08	24.17	38.33	-0.15	0.25	0.29
3-May-95	24.35	39.67	24.31	40.03	-0.04	0.36	0.36
8-Apr-95	24.43	38.08	24.52	38.35	0.09	0.27	0.28
3-Mar-95	25.55	38.00	25.66	38.31	0.11	0.31	0.32
25-Feb-95	23.76	37.75	23.79	38.02	0.03	0.27	0.27
27-Jan-95	24.42	38.85	24.60	39.40	0.18	0.55	0.57
17-Nov-94	24.67	38.43	24.63	38.71	-0.04	0.28	0.28
1-Oct-94	24.14	37.48	23.98	37.64	-0.16	0.16	0.23
20-Sep-94	23.81	37.90	23.50	38.07	-0.31	0.17	0.35
16-Aug-94	24.39	37.70	24.33	37.94	-0.06	0.24	0.24
21-Jul-94	23.85	37.22	23.77	37.28	-0.08	0.06	0.10
15-Jun-94	24.20	38.24	23.82	38.16	-0.38	-0.08	0.39
23-May-94	24.84	36.72	24.75	36.74	-0.09	0.02	0.09
26-Apr-94	24.40	38.77	24.15	39.08	-0.25	0.31	0.40
9-Mar-94	24.22	36.30	24.23	35.97	0.01	-0.33	0.32
9-Feb-94	23.51	38.50	24.02	39.00	0.51	0.50	0.71
21-Jan-94	23.73	38.54	24.08	38.52	0.35	-0.02	0.35
10-Dec-93	24.60	38.30	24.85	39.01	0.25	0.71	0.74
17-Nov-93	24.83	39.21	24.67	39.40	-0.16	0.19	0.25
27-Oct-93	25.41	37.50	25.60	37.73	0.19	0.23	0.30
10-Sep-93	24.00	37.80	23.80	38.50	-0.20	0.70	0.72
						Min	0.09
						Max	0.74
						Mean	**0.37**